BRITISH IRONCLADS 1860–75

HMS *Warrior* and the Royal Navy's 'Black Battlefleet'

ANGUS KONSTAM

ILLUSTRATED BY PAUL WRIGHT

NEW VANGUARD 262

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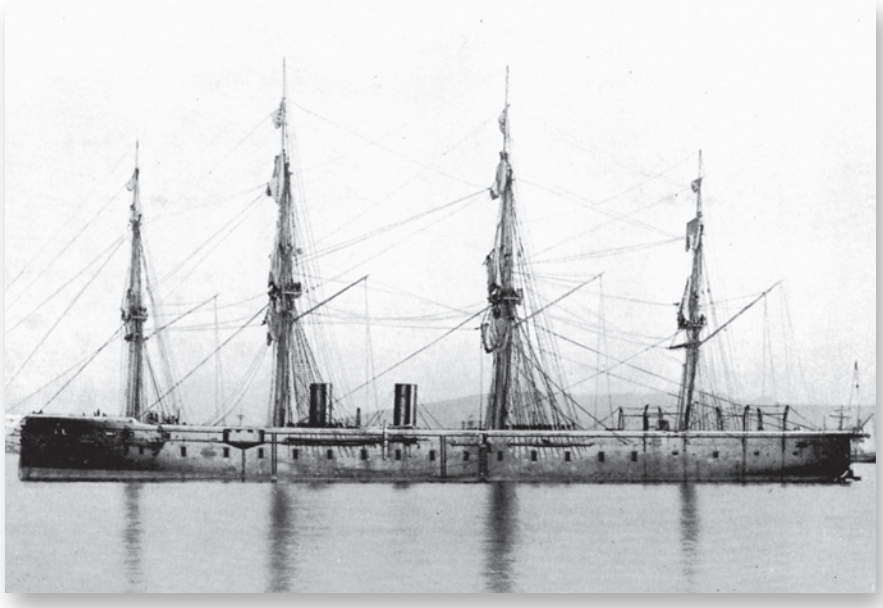

ANGUS KONSTAM ILLUSTRATED BY PAUL WRIGHT

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BRITISH IRONCLADS 1860–75

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INTRODUCTION

On 12 November 1859, Queen Victoria arrived in Portsmouth to witness the launch of her namesake, HMS *Victoria*. She was a steam-powered First Rate ship-of-the-line of 121 guns, the largest wooden-hulled warship ever built in Britain. In other words, she was the ultimate wooden-walled sailing warship – and she would be one of the last. Exactly ten years later, on 12 November 1869, and also in Portsmouth, the keel of HMS *Devastation* was laid. She was a mastless turret ship, the first of her kind. Effectively, she would be the world's first true battleship. Only a decade separated the two events, but the two ships were worlds apart. The first marked the end of the wooden-walled ships that established Britain's predominance as a maritime power. The second ensured the Royal Navy maintained that mantle after a decade of innovation like no other in naval history.

The commissioning of *Devastation* in 1873 marked the start of a new era in warship design. Today this is largely forgotten, overshadowed by a development that utterly transformed naval warfare. That was the launch of HMS *Warrior*, the world's first purpose-built seagoing iron warship. She was laid down in 1859 in response to the construction by the French of the

HMS *Warrior*, the world's first ocean-going ironclad, has been preserved and fully restored, and is now a floating museum ship, dominating the entrance to Portsmouth's Historic Dockyard. When she first entered service in the summer of 1861, *Warrior* was the most powerful warship in the world.

The ship's wheels of HMS *Warrior* on the upper deck were duplicated by these on the gun deck, and another set below them on the lower deck. This was not merely in case of damage – *Warrior* had a small rudder, and a lot of effort was needed to turn her, meaning all three sets would be fully manned while she was under way.

world's first seagoing ironclad. *Warrior*, though, was in a different league to her rival. She was a ship worthy of superlatives: a revolutionary iron-hulled ship, protected by iron plate, powered by reliable engines and armed with a potent battery of heavy guns. *Warrior* and the many ironclads that followed her represented the ultimate fusion of Victorian technological know-how and British naval might. The old ways represented by the *Victoria* were swept aside, and a new age of steam, steel and shell was born.

DESIGN AND DEVELOPMENT

Warrior

In the 1850s Britain might still have been the world's leading maritime power, but it was definitely resting on its laurels. During the Crimean War (1853–56) the French had built iron-clad floating batteries which proved impervious to Russian shot. Even though these were not seagoing vessels, they still represented the future of naval warfare. The French were so impressed that they developed their own seagoing version, a wooden-hulled steam-powered warship which had been cut down, then had iron plates attached to her hull. This ship, *La Gloire* ('Glory'), duly became the world's first seagoing ironclad warship. She was still under construction when news of her reached Britain. It was quickly realized that this new warship was more than a match for the wooden-hulled ships-of-the-line which formed Britain's battlefleet. If Britain was to maintain its naval standing, then something had to be done, and done quickly.

Reluctantly goaded into action, the Admiralty responded by calling for proposals from commercial firms for an iron-clad warship which could provide an antidote to this French threat. Of the dozen or so responses, all but two called for an iron-hulled vessel. The Admiralty had experimented with iron-hulled ships during the 1840s, but found them vulnerable to enemy

The initial design requirements for *Warrior* were drawn up by Sir Baldwin Wake Walker, Surveyor of the Navy from 1848–60. However, the final design work was carried out by his successor Isaac Watts and the Navy's Chief Engineer Thomas Lloyd. Walker is shown here in the uniform of the Turkish Navy, having served with them during the early 1840s.

fire. The metal would shatter when hit, forming lethal jagged shards. However, recent experiments had shown that iron plate at least 4in thick was virtually impervious to shot and shell. So, with no great enthusiasm, the Admiralty selected the best proposal, the Navy's Chief Constructor Isaac Watts adapted the plans, then contracts were issued for the building of two of these vessels. The *Warrior* would be built on the Thames, and her sister ship *Black Prince* on the Clyde. Their novel iron construction meant they had to be built in commercial yards, as the royal dockyards had no experience in the building of iron ships.

These ships were a mix of the old and the new. Their guns were arrayed in long broadsides, just like a sailing man-of-war, and they could be powered by either steam or sail. They were classified as frigates as they had only one gun deck. However, for all practical purposes they were capital ships – what might have been called ships-of-the-line in the wooden-walled navy. They were dubbed 'ironclads' due to their armoured protection, and the term stuck and was applied to the warships which succeeded them. At the time there was no sense that this represented a revolution in ship design. That, though, was exactly what was happening.

Warrior Class	
Type	broadside ironclad (two in class)
Displacement	9,137 tons (*Black Prince* 9,250 tons)
Dimensions	length 380ft (115.87m) between perpendiculars, 420ft (128m) overall; beam 58ft 4in (17.78m); draught 26ft (7.92m)
Propulsion	single shaft, powered by a Penn horizontal trunk steam engine and ten boilers, generating 5,267ihp (*Black Prince* 5,770ihp)
Maximum speed	14.1 knots (*Black Prince* 13.6 knots)
Coal bunkerage	850 tons
Armour	belt: 4.5in iron with 18in wood backing; bulkheads: 4.5in iron
Armament (1867)	four 8in rifled muzzle-loaders (RMLs), 28 7in RMLs (*Black Prince* 24 7in RMLs), four 20-pdr breach-loaders (BLs)
Complement	707

Ship	Builder	Laid Down	Launched	Completed	Fate
Warrior	Ditchburn & Mare, Blackwall	May 1859	December 1860	October 1861	Preserved as museum ship, Portsmouth
Black Prince	Napier, Clydeside	October 1859	February 1861	September 1862	Broken up 1923

The term the 'Black Battlefleet' was used to encompass Britain's entire force of ironclads, the term referring to their all-black hulls, broken only by a white trim around the gunwale. In this watercolour by an anonymous artist, painted in 1875, *Devastation* and *Monarch* lead a cluster of broadside and casemate battery ironclads during manoeuvres in the English Channel.

Above all, *Warrior* and her sister were designed to take on and defeat *La Gloire*. They were faster, better protected and better armed than their French rival, and unlike *La Gloire* they were true ocean-going vessels, as befitted a navy with global commitments. They had their limitations though. Their armoured belts covered only part of their gun decks. The rest of their hulls were unprotected, including their steering gear. These faults would be rectified in the ironclads which followed.

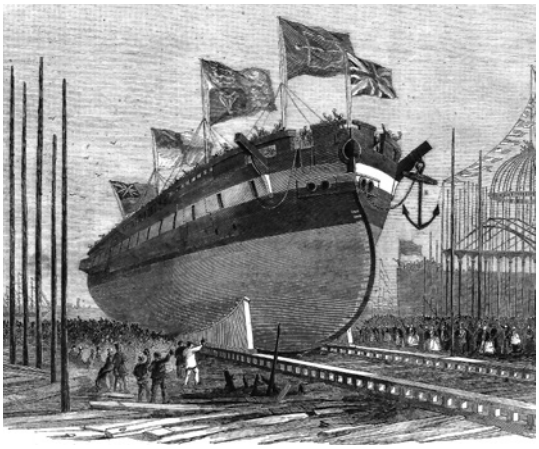
Warrior was built quickly. She was laid down in May 1859, and she entered service in October 1861, 14 months behind her French rival. That, though, was only the start. Within two months a second British ironclad, the *Defence*, would enter service, while in 1862 *Defence*'s sister *Resistance* would join the fleet, followed by the *Black Prince*. These four warships formed the nucleus of Britain's new ironclad battlefleet. The Warrior class, and eventually all those that followed, all bore the same colour scheme. Ochre funnels and masts rose above the ships' sides, which were painted a uniform black, relieved only by a white trim around the upperworks. Inevitably, they collectively became known as the 'Black Battlefleet'. This was a battlefleet which broke centuries of tradition, and which continually evolved as new designs and new technology led to the building of ever-more-potent ironclads.

Defence Class	
Type	broadside ironclad (two in class)
Displacement	6,150 tons (*Resistance* 6,070 tons)
Dimensions	length 280ft (85.3m) between perpendiculars, 302ft (92.04m) overall; beam 54ft 2in (16.51m); draught 25ft (7.62m)
Propulsion	single shaft, powered by a Penn horizontal trunk steam engine and four boilers, generating 2,540ihp (*Resistance* 2,430ihp)
Maximum speed	11.6 knots (*Resistance* 11.8 knots)
Coal bunkerage	460 tons
Armour	belt: 4.5in iron with 18in wood backing; bulkheads: 4.5in iron
Armament (1867)	two 8in RMLs, 14 7in RMLs
Complement	460

Ship	**Builder**	**Laid Down**	**Launched**	**Completed**	**Fate**
Defence	Palmers, Jarrow	December 1859	April 1860	December 1861	Broken up 1935
Resistance	Westwood & Baillie, Millwall	December 1859	April 1861	July 1862	Sold out of service 1898, subsequently foundered (1899) and broken up

Broadside ironclads

The *Warrior* and *Black Prince* were followed by a number of smaller versions following the same design, the first being *Defence* and *Resistance*. They displaced 6,150 tons, carried 16 guns and made only 12 knots. However, their armoured belts, otherwise identical to *Warrior*, extended the length of their gun decks. The ends of these ships, and their steering gear, remained the same. Being shorter than *Warrior* they were much more manoeuvrable. In 1860 three more ironclads were ordered. The two ironclad frigates of the Hector class were broadly similar to the Defence class, but they displaced 6,710 tons owing to their heavier armour, which now extended the full length of the ship.



ABOVE LEFT
When they were first launched in April 1861, HMS *Resistance* (shown here) and her sister ship HMS *Defence* were painted in the traditional manner for a frigate, with a white band running along the line of her gun ports. Both ships were repainted in the late 1860s to conform to the all-black style preferred for British ironclads.

ABOVE RIGHT
The small broadside ironclad HMS *Defence* and her sister ship *Resistance* were essentially smaller versions of the Warrior class, designed and built at speed to counter the threat posed by the nascent French ironclad fleet. Unlike *Warrior* though, these vessels were fitted with a ram bow.

Achilles was a modified version of *Warrior*, with an armoured belt extending the full length of her hull, of the same thickness as *Warrior*, but tapering to 2.5in outside the gun deck. This time her steering gear was fully protected. At 9,829 tons, *Achilles* displaced more than *Warrior*, although her hull was the same length. However, while the Warrior class had elegant clipper bows, these five new ironclads had blunter stems, with a ram at the prow. This represented a break with tradition in the building of British warships, so the Admiralty classed the four smaller vessels as 'steam rams'. They were soon re-labelled as second line armoured ships.

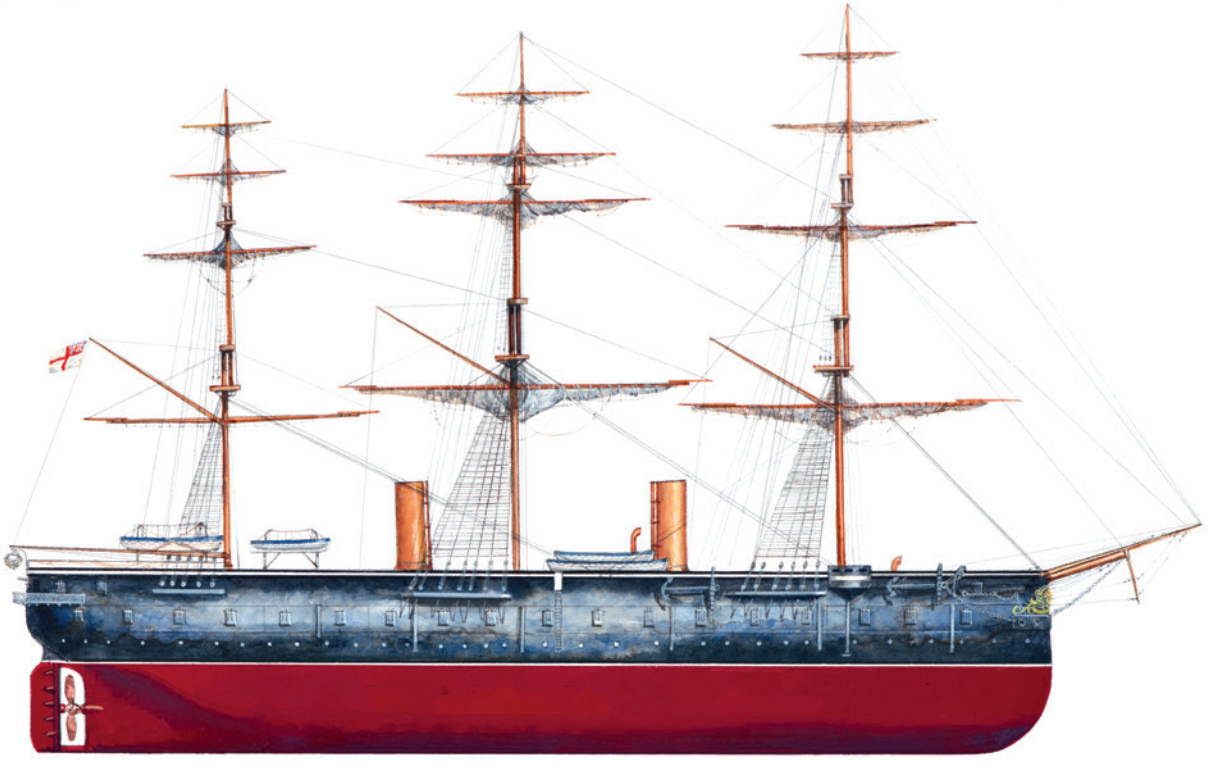
Hector Class	
Type	broadside ironclad (two in class)
Displacement	6,710 tons
Dimensions	length 280ft 2in (85.39m) between perpendiculars; beam 56ft 3in (17.4m); draught 25ft (7.62m)
Propulsion	single shaft, powered by a Maudslay horizontal return connecting rod steam engine and six boilers, generating 3,260ihp (*Valiant* 3,560ihp)
Maximum speed	12.6 knots (*Valiant* 12.4 knots)
Coal bunkerage	450 tons
Armour	belt: 4.5in iron; bulkheads: 4.5in iron; battery: 4.5in iron
Armament	two 8in RMLs, 16 7in RMLs
Complement	530

A

HMS *ACHILLES* & HMS *PRINCE CONSORT*

The *Achilles* (top) was an improved version of the Warrior class, and followed the same basic design, including size and hull shape. However, she had four masts, which between them carried 44,000 square feet of sail – the largest spread of canvas ever seen in a British warship. They proved unsatisfactory though, and in 1865–66 various alternative rigs were tried, which resulted in *Achilles* losing a mast. Similarly, her armament changed during her first five years, and by 1868 her smoothbores had been replaced by rifled muzzle-loaders. She remained on the active list until 1885.

Unlike *Achilles, Prince Consort* (bottom) began life as a 91-gun steam-powered Second Rate ship-of-the-line, but in 1861, while still on the stocks, she and her two sister ships were rebuilt as ironclads. This was done in response to the rapid growth of the French fleet. The two-deckers were lengthened to accommodate the extra machinery and armour required, and their hulls were strengthened before the iron cladding was applied to their outer hulls. In the case of the Prince Consort class, this process was less successful than with some other wooden-hulled ironclads, as they were slow and rolled badly. Still, *Prince Consort* and her sisters were capable of holding their own in battle against their French ironclad counterparts, and so proved their worth as a cost-effective stopgap. Both ships are shown here as they appeared in the spring of 1865, while serving with the Channel Fleet.



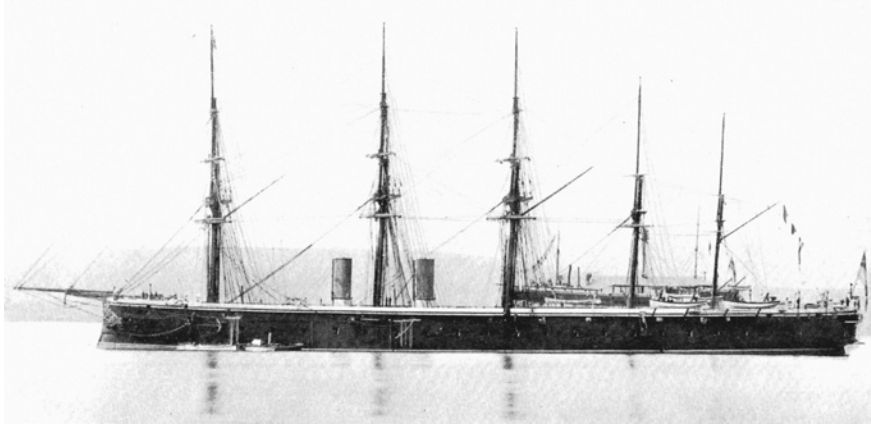
Ship	Builder	Laid Down	Launched	Completed	Fate
Hector	Napier, Clydeside	March 1861	September 1862	February 1864	Broken up 1905
Valiant	Westwood & Baillie, Millwall, & Thames Iron Works, Bow	February 1861	October 1863	September 1868	Broken up 1957

Achilles was completed in late 1864, by which time the Admiralty had ordered three even bigger iron-hulled warships. These were enlarged versions of the *Achilles*, and were all laid down in late 1861, just a few months after *Achilles*, but around the same time *Warrior* was completed. The most visible difference between these three ships (*Minotaur*, *Agincourt* and *Northumberland*) and the three preceding large ironclads was their five masts. In theory this and their large press of sail should have made them fast under canvas, but their displacement rendered them mediocre performers under wind power. By contrast though, all three ships could make over 14 knots under steam.

Achilles Class	
Type	broadside ironclad (one in class)
Displacement	9,829 tons
Dimensions	length 380ft (115.82m) between perpendiculars; beam 58ft 4in (17.77m); draught 27ft 3in (8.31m)
Propulsion	single shaft powered by a Penn horizontal trunk steam engine and ten boilers, generating 5,720ihp
Maximum speed	14.3 knots
Coal bunkerage	740 tons
Armour	belt: 4.5in iron with 18in wood backing; bulkheads: 4.5in iron; battery: 4.5in iron
Armament (1868)	four 8in RMLs, 22 7in RMLs
Complement	709

Ship	Builder	Laid Down	Launched	Completed	Fate
Achilles	Chatham Dockyard	August 1861	December 1863	November 1864	Broken up 1925

They displaced around 1,000 tons more than *Achilles*, most of which was due to their extra armour. In the Minotaur class the armour covered the whole ship's side, from the level of the upper deck to well below the



The Minotaur class represented the ultimate development of the broadside ironclad. The *Minotaur*, shown here, had a powerful armament of 36 rifled guns, with an armoured belt that ran the full length of her long hull. *Minotaur* and her two sister ships were the only five-masted ironclads in British service.

waterline. Over the long gun battery this belt was an inch thicker than in the previous ironclads, while an armoured bulkhead at the forward end of the gun deck offered additional protection. *Minotaur* was completed in 1865, but spent the next 18 months trying out various sailing rigs and armament configurations, and so the completion of the other ships was delayed until these trials were complete. In the end they all entered service during 1867–68.

Minotaur Class	
Type	broadside ironclad (three in class)
Displacement	*Agincourt* 10,600 tons, *Minotaur* 10,690 tons, *Northumberland* 10,784 tons
Dimensions	length 400ft 3in (122m) between perpendiculars, 407ft (124m) overall; beam 59ft 6in (18.4m); draught 27ft 9in (8.46m)
Propulsion	single shaft, powered by a Penn two-cylinder horizontal trunk steam engine (*Agincourt*, Maudslay return connecting rod steam engine) and ten boilers, generating 6,700ihp (*Minotaur*), 6,867ihp (*Agincourt*), 6,545ihp (*Northumberland*)
Maximum speed	14.1 knots (*Minotaur* 14.3 knots)
Coal bunkerage	750 tons
Armour	belt and battery: 5.5in iron amidships, reducing to 4.5in at extremities, with 10in wood backing; bulkheads: 5.5in iron
Armament	*Minotaur* & *Agincourt*: four 9in RMLs, 24 7in RMLs, eight 24-pdr RMLs *Northumberland*: four 9in RMLs, 22 8in RMLs, two 7in RMLs
Complement	800

Ship	**Builder**	**Laid Down**	**Launched**	**Completed**	**Fate**
Minotaur	Thames Iron Works, Bow	September 1861	December 1863	December 1868	Broken up 1922
Agincourt	Lairds, Birkenhead	October 1861	March 1865	June 1867	Broken up 1960
Northumberland	Millwall Iron Works, Millwall	October 1861	April 1866	October 1868	Sold out of service 1927, as hulk

By then *Northumberland* had been modified slightly, having her armour beyond the gun deck removed, and armoured bulkheads fitted. This was done to compensate for her heavy armament. When the Minotaur-class ships entered service they were the largest ironclads in the world. Still, they had their critics, and many felt they were unnecessarily little more than a vanity project for their designer Isaac Watts. One of these critics, Edward Reed, actually succeeded Watts as the Navy's Chief Constructor in 1863, and promptly abandoned the broadside ironclad in favour of his own design.

The Prince Consort class wooden-hulled broadside ironclad HMS *Caledonia*, pictured at her moorings in Valetta Harbour in Malta in 1868. At the time, she was the flagship of the Mediterranean Fleet, so becoming the first flagship ironclad in the Royal Navy.

The wooden conversions

In early 1861, while *Warrior* was still fitting out, word reached the Admiralty that the French were about to build ten more ironclads. It was impossible to increase the naval budget to counter this, but the Controller of the Navy suggested a pragmatic solution. All of the French ironclads were wooden-hulled ships, protected by iron plate, so he suggested converting wooden-hulled warships currently under construction into wooden-hulled ironclads, built along French lines. The Admiralty embraced this stop-gap

solution, and plans were drawn up. This was an important moment in naval construction. Even before *Warrior* entered service, the era of the wooden-hulled ship-of-the-line had come to an end. From that moment on, all British capital ships would be protected by armour.

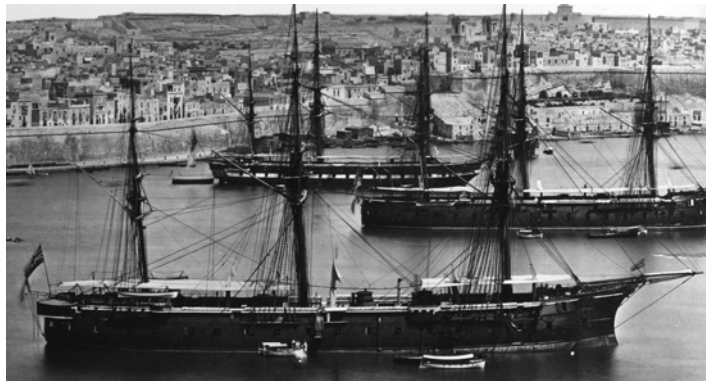
The first ship to be converted was the *Royal Oak*, laid down in Chatham the previous year. She was being built as a screw-propelled two-deck ship-of-the-line of 90 guns, but from June 1861 she was completely rebuilt. First, her upper deck was cut down and her hull was also lengthened by 21ft (6.4m) to accommodate her guns, which would now be carried on a single gun deck. Iron plates were then fitted to her wooden sides, so that when finished she carried a similar armoured belt to the *Warrior*. There was no need for wooden backing as her oak sides were already 28in (71cm) thick. This dramatically modified ship was launched in the autumn of 1863, and entered service seven months later.

The *Royal Oak* was the first of several vessels to undergo this conversion. She had been laid down as a Bulwark-class steam-powered ship-of-the-line. Of these, five were cancelled, while the remaining eight became wooden-hulled broadside ironclads. The *Royal Oak* was one of a kind, and formed her own class. The *Triumph* was renamed the *Prince Consort* while under construction and became the namesake of a new ironclad class, together with *Caledonia* and *Ocean*. All of these four ships were wooden-hulled broadside ironclads, of roughly the same size as the ships of the Defence and Hector classes. All had a similar displacement, but carried a slightly larger armament of 24 guns.

Prince Consort Class	
Type	wooden-hulled broadside ironclad (three in class)
Displacement	6,832 tons
Dimensions	length 273ft (83.21m) between perpendiculars; beam 58ft 6in (17.83m); draught 24ft (7.31m)
Propulsion	single shaft, powered by a Maudslay horizontal return connecting rod steam engine and eight boilers, generating 1,000ihp
Maximum speed	12.5 knots (*Caledonia* 12.9 knots)
Coal bunkerage	550 tons
Armour	belt and battery: 4.5in iron amidships, reducing to 3in at extremities
Armament (1867)	four 8in RMLs, 20 7in RMLs
Complement	605

Ship	Builder	Laid Down	Launched	Completed	Fate
Prince Consort	Pembroke Dockyard	August 1860	June 1862	April 1864	Broken up 1882
Caledonia	Woolwich Dockyard	October 1860	October 1862	July 1865	Broken up 1886
Ocean	Devonport Dockyard	August 1860	March 1862	July 1865	Broken up 1882

Three other former Bulwark-class ships, *Royal Alfred*, *Zealous* and *Repulse*, were all slightly different from each other, but were of similar size and displacement. Work on them was delayed pending trials of the first batch of conversions, by which time the Constructor in charge of their conversion was Edward Reed, who grouped the guns amidships inside an armoured box. In *Royal Alfred*, this armour was 6in thick. The belt extended the full length of the ship, and below the waterline, but outside the central battery its thickness was reduced. Incidentally, *Repulse*, completed in 1870, was the last wooden capital ship to enter service with the Royal Navy.



Royal Oak Class	
Type	wooden-hulled broadside ironclad (one in class)
Displacement	6,366 tons
Dimensions	length 273ft (83.21m) between perpendiculars; beam 58ft 3in (17.75m); draught 24ft (7.31m)
Propulsion	single shaft, powered by a Maudslay horizontal connecting rod steam engine and six boilers, generating 3,000ihp
Maximum speed	12.5 knots
Coal bunkerage	550 tons
Armour	belt and battery: 4.5in iron
Armament (1867)	four 8in RMLs, 20 7in RMLs
Complement	585

Ship	Builder	Laid Down	Launched	Completed	Fate
Royal Oak	Chatham Dockyard	May 1860	September 1862	April 1863	Mothballed 1871, broken up 1885

ABOVE LEFT
HMS *Zealous*, pictured off the western coast of Canada during the early 1870s. During her lengthy deployment in the Pacific she operated almost entirely under sail because of the scarcity of suitable stocks of coal. Like most other wooden-hulled ships which had been converted into ironclads, she lacked the strength of her iron-built contemporaries. *Zealous* was relegated to reserve duties by 1873, and was laid up two years later.

ABOVE RIGHT
The wooden-hulled broadside ironclad HMS *Lord Warden*, pictured in Malta in 1871. Behind her is her sister ship *Lord Clyde*, which was built using rotten timbers, and so was decommissioned in 1872.

Two other wooden conversions were the *Lord Clyde* and the *Lord Warden*, which were actually purpose-built wooden-hulled broadside ironclads, built to use up the large stock of unwanted timber in the royal dockyards. These were among the heaviest wooden ships ever built, and probably the slowest ironclads under sail. They were plagued by problems – *Lord Warden* by accidents and *Lord Clyde* by rotten timbers. After nine years both ships were taken out of active service. In fact, this reflected the fate of other wooden-hulled ironclads. As the ships aged, their timbers suffered from the added weight of their armoured cladding, and so within a decade most were either laid up or placed in reserve. What they did, though, was fill the ranks of the 'Black Battlefleet' while other iron-hulled warships were being built.

Royal Alfred Class	
Type	wooden-hulled broadside ironclad (one in class)
Displacement	6,707 tons
Dimensions	length 273ft (83.21m) between perpendiculars; beam 58ft 6in (17.83m); draught 25ft 5in (7.75m)
Propulsion	single shaft, powered by a Maudslay horizontal connecting rod steam engine and six boilers, generating 3,230ihp
Maximum speed	12.4 knots
Coal bunkerage	550 tons
Armour	belt and battery: 6in iron; bulkheads: 4.5in iron
Armament (1867)	ten 9in RMLs, eight 7in RMLs
Complement	605

Ship	Builder	Laid Down	Launched	Completed	Fate
Royal Alfred	Portsmouth Dockyard	December 1859	October 1864	March 1867	Broken up 1885

Zealous Class	
Type	wooden-hulled broadside ironclad (one in class)
Displacement	6,096 tons
Dimensions	length 252ft (76.81m) between perpendiculars; beam 58ft 6in (17.83m); draught 25ft 5in (7.75m)
Propulsion	single shaft, powered by a Maudslay horizontal return connecting rod steam engine and six boilers, generating 3,623ihp
Maximum speed	11.7 knots
Coal bunkerage	660 tons
Armour	belt and battery: 4.5in iron; bulkheads: 3in iron
Armament	20 7in RMLs
Complement	510

Ship	Builder	Laid Down	Launched	Completed	Fate
Zealous	Pembroke Dockyard	October 1859	March 1864	October 1866	Mothballed 1875, broken up 1885

Repulse Class	
Type	wooden-hulled broadside ironclad (one in class)
Displacement	6,190 tons
Dimensions	length 252ft (76.81m) between perpendiculars; beam 59ft (17.98m); draught 24ft (7.31m)
Propulsion	single shaft, powered by a Penn horizontal trunk steam engine and six boilers, generating 3,350ihp
Maximum speed	12.5 knots
Coal bunkerage	460 tons
Armour	belt and battery: 6in iron; bulkheads: 4.5in iron
Armament	12 8in RMLs
Complement	515

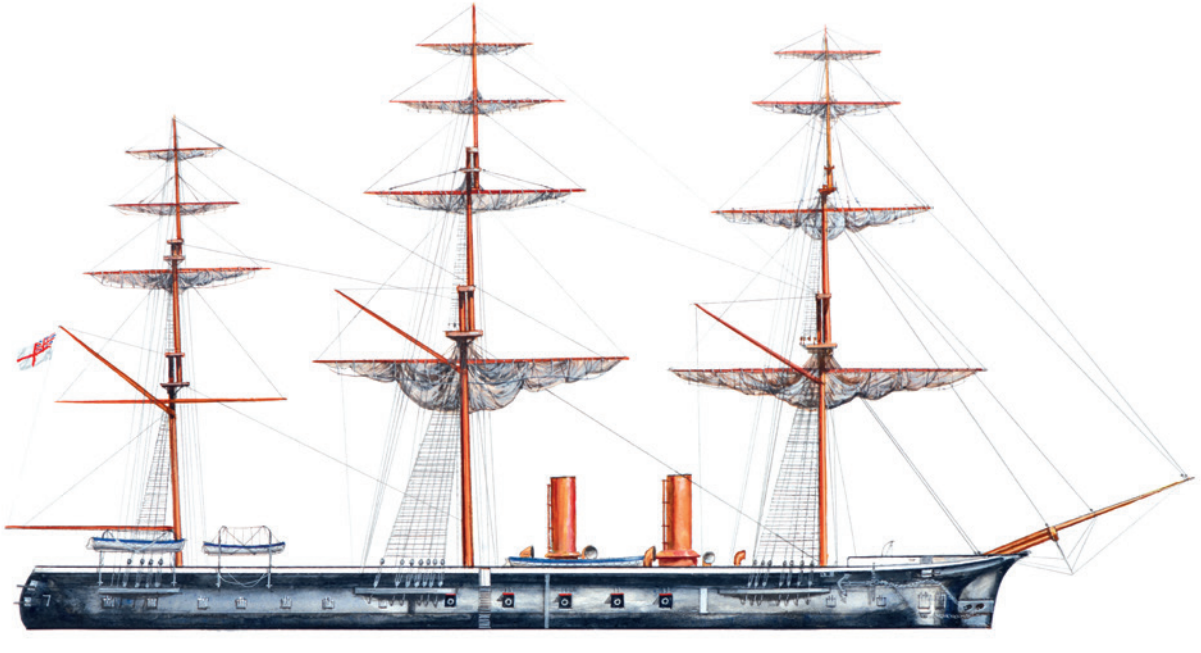
Ship	Builder	Laid Down	Launched	Completed	Fate
Repulse	Woolwich & Sheerness Dockyards	April 1859	April 1868	January 1870	Mothballed 1885, broken up 1889

B

HMS *AGINCOURT* & HMS *BELLEROPHON*

The broadside ironclad *Agincourt* (top) and her sister ships *Minotaur* and *Northumberland* were truly magnificent-looking ships, and represented the ultimate development of the large iron-hulled broadside ironclad design that began with *Warrior* and *Black Prince*, then evolved into the four-masted *Achilles*. Effectively, they were designed to be protected by the thickest armour afloat and to move at the greatest possible speed. The Minotaur class differed from *Warrior* in having an armoured deck that ran the whole length of the hull. This meant there were no armoured bulkheads to break up the impressively long expanse of gun deck. The most notable feature of *Agincourt* and her sisters though, were their five masts, the last two carrying spanker sails, but despite this they still had a reputation as being poor performers under sail. *Agincourt* spent most of her career serving with the Channel Fleet, and remained in active service until 1889.

While *Agincourt* represented the ultimate broadside ironclad, the *Bellerophon* (bottom) was effectively the first of a new breed of ironclad, where the armament was concentrated in a box battery amidships. This design came to be known as the central battery ironclad, although in her outward appearance *Bellerophon* looked little different from her broadside-armed predecessors. This pioneering design incorporated other innovations too, such as a balanced rudder and a complete rather than a partial double bottom, which gave her added protection in the event of a grounding, a ramming or a torpedo hit. *Bellerophon* spent much of her life as the flagship of the North America station.



Sir Edward Reed succeeded Isaac Watts as the Royal Navy's Chief Constructor in 1863, and held the post for seven years. He was a leading proponent of the central battery, but his real triumph was the development of the mastless turret ship.

Lord Clyde Class	
Type	wooden-hulled broadside ironclad (two in class)
Displacement	*Lord Clyde* 7,750 tons, *Lord Warden* 7,842 tons
Dimensions	length 280ft (85.34m) between perpendiculars; beam 59ft (17.98m); draught 26ft (7.92m)
Propulsion	*Lord Clyde*: single shaft, powered by a Ravenhill two-cylinder horizontal trunk steam engine and eight boilers, generating 6,064ihp; *Lord Warden*: single shaft, powered by a Maudslay three cylinder return connecting rod steam engine and nine boilers, generating 6,700ihp
Maximum speed	*Lord Clyde* 13.4 knots, *Lord Warden* 13.5 knots
Coal bunkerage	600 tons
Armour	belt and battery: 5.5in iron amidships, reducing to 4.5in at extremities, with 6in wooden backing
Armament (1867)	two 9in RMLs, 14 8in RMLs, two 7in RMLs, two 20-pdr BLs (saluting guns)
Complement	605

Ship	Builder	Laid Down	Launched	Completed	Fate
Lord Clyde	Pembroke Dockyard	September 1863	October 1864	June 1866	Broken up 1875
Lord Warden	Chatham Dockyard	December 1863	March 1865	August 1867	Broken up 1889

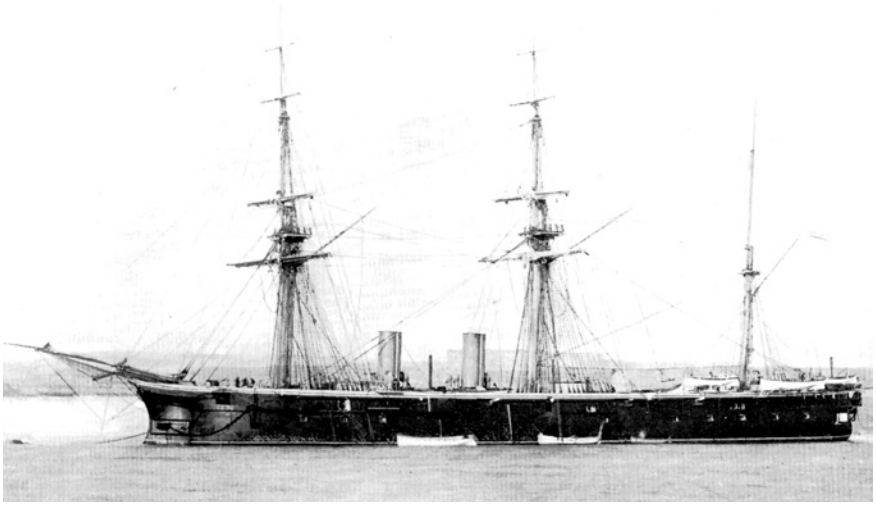
Central battery ironclads

In 1863, when Edward Reed succeeded Isaac Watts as Chief Constructor he abandoned his predecessor's commitment to broadside ironclads. Reed had his own vision of smaller and more manoeuvrable capital ships, which were fast but also armed with the heaviest guns available. His first ship was the *Bellerophon*, which carried most of her guns in a central battery, protected by 6in of armour. This armoured box was closed off by armoured bulkheads at either end, with additional armour protecting bow chasers at the forward end of the main deck. Below the waterline *Bellerophon* had a double bottom – the first complete double bottom of any British capital ship. She also had a new system of hull framing, and numerous watertight bulkheads below the waterline.

Bellerophon Class	
Type	central battery ironclad (one in class)
Displacement	7,551 tons
Dimensions	length 300ft (91.44m) between perpendiculars; beam 56ft 1in (17.09m); draught 24ft 8in (7.52m)
Propulsion	single shaft, powered by a Penn two-cylinder horizontal trunk steam engine and eight boilers, generating 6,521ihp
Maximum speed	14.2 knots
Coal bunkerage	640 tons
Armour	belt: 6in iron with 10in wood backing; bulkheads: 5in iron; conning tower: 5in iron
Armament	ten 9in RMLs, five 7in RMLs
Complement	650

Ship	Builder	Laid Down	Launched	Completed	Fate
Bellerophon	Chatham Dockyard	December 1863	May 1865	April 1866	Broken up 1922

Bellerophon also benefited from a balanced rudder, making it easier for the helmsman to turn the ship. This meant she could turn around in 559 yards (511m), as opposed to 1,050 yards (960m) for *Warrior*. She was fitted with an armoured conning tower abaft the mainmast. The advantage of the central battery system was that it allowed a smaller number of heavier



HMS *Bellerophon* was the first central battery ironclad in British service, and so she represented a major step forward in warship design. She had better armoured protection than the broadside ironclads that preceded her, and she was the first major British warship to incorporate a full double bottom, which improved her chances of survival if she was rammed or torpedoed.

guns to be carried. The size of British naval ordnance was growing steadily, and *Bellerophon*'s ten 9in rifled muzzle-loaders (RMLs) made her one of the most powerfully armed ironclads in the 'Black Battlefleet'. *Bellerophon* represented a major step forward in ironclad design, as the ship was well armed, fast, manoeuvrable and well protected. Reed would develop this central battery design further, but it was *Bellerophon* that marked the start of this new phase in British naval architecture.

Hercules Class	
Type	central battery ironclad (one in class)
Displacement	8,830 tons
Dimensions	length 325ft (99.06m) between perpendiculars; beam 59ft (17.98m); draught 25ft 4in (7.72m)
Propulsion	single shaft, powered by a Penn two-cylinder horizontal trunk steam engine and nine boilers, generating 7,178ihp
Maximum speed	14.7 knots
Coal bunkerage	610 tons
Armour	belt: 9in iron, reducing to 6in at extremities, with 10–20in wood backing; bulkheads: 5–6in iron; battery: 6–8in iron
Armament	eight 10in RMLs, two 9in RMLs, four 7in RMLs
Complement	638

Ship	Builder	Laid Down	Launched	Completed	Fate
Hercules	Chatham Dockyard	February 1866	February 1868	November 1868	Broken up 1932

The next step in the evolution of the central battery, as in the *Hercules* permitted some degree of all-round fire, thanks to recesses which allowed some guns to fire forward or aft. In the background is the *Devastation*. She and her sister ship *Thunderer* represented a revolution in warship design, although at the time these mastless warships were viewed with considerable scepticism.

Hercules, laid down in early 1866, was an enlarged version of *Bellerophon*, capable of carrying heavier 10in guns, and with an even thicker 9in protective belt, reducing to 6in outside the central battery. Unlike *Bellerophon* she had recessed ports at either end of her battery, to permit something akin to end-on fire – in other words firing as close to directly ahead or astern as possible. *Hercules* entered service in late 1868, the same year as *Minotaur* and *Northumberland*, yet she was already a generation ahead of them in ship design.

Audacious Class	
Type	central battery ironclad (four in class)
Displacement	6,010 tons
Dimensions	length 280ft (85.34m) between perpendiculars; beam 54ft (16.46m); draught 22ft 7in (6.88m)
Propulsion	twin shafts, powered by two 2 cylinder horizontal return connecting rod steam engines and six boilers, generating (*Audacious*) 4,020ihp; (*Invincible*) 4,830ihp; (*Iron Duke*) 4,270ihp; (*Vanguard*) 4,830ihp
Maximum speed	*Audacious*: 13.2 knots; *Invincible*: 14.1 knots; *Iron Duke*: 13.6 knots; *Vanguard*: 14.5 knots
Coal bunkerage	460 tons
Armour	belt: 8in iron reducing to 6in at extremities, with 8–10in wood backing; bulkheads: 5in iron; battery: 6in iron
Armament	ten 9in RMLs, four 6in RMLs, six 20-pdr BLs (saluting guns)
Complement	450

Ship	Builder	Laid Down	Launched	Completed	Fate
Audacious	Napier, Clydeside	June 1867	February 1869	September 1870	Broken up 1922
Invincible		June 1867	May 1869	October 1870	Foundered off Portland, 1914
Iron Duke	Pembroke Dockyard	August 1868	March 1870	January 1871	Broken up 1906
Vanguard	Laird, Birkenhead	October 1867	January 1870	September 1870	Sunk in collision, 1 September 1876

The *Iron Duke* was one of four Audacious-class central battery ironclads to join the fleet during the winter of 1870–71. They were designed for use on foreign stations – primarily the Mediterranean Fleet – and so had a shallower draught than most of their contemporaries.

The Audacious class of four vessels, which followed soon after *Hercules*, were designed as 2nd class ironclads, intended for service in foreign stations such as the Mediterranean Fleet or the American and West Indies Station. *Audacious*, *Invincible*, *Iron Duke* and *Vanguard* had an even more centralized battery than *Bellerophon* or *Hercules*, split over two decks. The main battery of 9in RMLs fired through regular broadside ports, but the two 6in RMLs on each side of the upper battery were mounted in corner casemate ports, capable of firing ahead or astern, or to the beam. Each of these

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IRONCLADS IN THE MEDITERRANEAN, 1868

The wooden-hulled ironclads *Royal Oak* and *Lord Clyde* both served with the Mediterranean Fleet, the former from 1863 until 1871, when she was sent home for a refit, and the latter from 1868 until 1870, when she returned home to have a new engine fitted. *Royal Oak* was never recommissioned, and while the *Lord Clyde* returned to the Mediterranean in 1871, within a year she was back in Britain, having run aground off the island of Pantellaria, which caused sufficient damage to her timbers that she required extensive repairs. After being patched up in Malta she returned to Britain, where she was decommissioned and eventually scrapped. So, neither ship can really be regarded as particularly successful, and like most ironclads converted from wooden-hulled vessels they had relatively short careers.

This scene is set in the autumn of 1868 while the Mediterranean Fleet was cruising off the Spanish Mediterranean coast, during a period of escalating tension following a revolution in Spain, the abdication of Queen Isabella II and the founding of a Spanish Republic. *Royal Oak* is the ship in the centre of this line, with *Lord Clyde* following astern. In the interest of showing a range of ironclads, we have taken the liberty of adding the central battery ironclad *Hercules* to the squadron, even though she was serving with the Channel Fleet at the time, only becoming the Mediterranean flagship in 1874. *Hercules* was a powerful addition to any fleet, with her main battery of 10in RMLs mounted inside her armoured casemate, which had embrasures in it to allow the first and last guns in each battery to train fore and aft.

batteries was well protected by an armoured box. Like those before them, these ships were fitted with a simple blunt ram, the effectiveness of which was demonstrated in 1875, when *Vanguard* was accidentally rammed and sunk by *Iron Duke*.

Sultan Class	
Type	central battery ironclad (one in class)
Displacement	9,540 tons
Dimensions	length 325ft (99.06m) between perpendiculars; beam 59ft (17.98m); draught 26ft 5in (8.05m)
Propulsion	single shaft, powered by a Penn two-cylinder horizontal trunk steam engine and eight boilers, generating 7,720ihp
Maximum speed	14.1 knots
Coal bunkerage	740 tons
Armour	belt: 9in iron, reducing to 6in at extremities, with 10–12in wood backing; bulkheads: 4.5–6in iron; main battery: 9in iron; upper battery: 8in iron
Armament	eight 10in RMLs, four 9in RMLs, seven 20-pdr BLs (saluting guns)
Complement	633

Ship	**Builder**	**Laid Down**	**Launched**	**Completed**	**Fate**
Sultan	Chatham Dockyard	February 1868	May 1870	October 1871	Broken up 1946

Other central battery ironclads followed. *Sultan* was an improved version of *Hercules*, which incorporated the Audacious-class notion of a split-level central battery. This replaced the embrasures fore and aft in the main gun deck, as a pair of 9in RMLs in upper-deck level embrasures provided end-on fire. So too did another pair of 9in guns carried as bow chasers on the forecastle, protected by an armoured bulkhead. The two smaller central battery ironclads of the Swiftsure class were 2nd class ironclads, designed for service in the Far East. Unusually, they were sheathed in wood and copper, to protect their iron lower hulls from fouling. When *Swiftsure* and *Triumph* entered service in 1872–73 they were the last British capital ships to be fitted with lifting mechanisms for their propellers.

Swiftsure Class	
Type	central battery ironclad (two in class)
Displacement	*Swiftsure* 6,910 tons *Triumph* 6,640 tons
Dimensions	length 280ft (85.34m) between perpendiculars; beam 55ft (16.76m); draught 25ft (7.62m)
Propulsion	single shaft, powered by a Maudslay two cylinder horizontal return connecting rod steam engine and six boilers, generating; *Swiftsure*: 4,910ihp *Triumph*: 4,890ihp
Maximum speed	*Swiftsure* 13.8 knots, *Triumph* 14.1 knots
Coal bunkerage	550 tons
Armour	belt: 8in iron, reducing to 6in at extremities, with 8–10in wood backing; bulkheads: 4–5in iron; battery: 6in iron
Armament	ten 9in RMLs, four 6in RMLs, six 20-pdr BLs (saluting guns)
Complement	450

Ship	**Builder**	**Laid Down**	**Launched**	**Completed**	**Fate**
Swiftsure	Palmers, Jarrow	August 1868	June 1870	June 1872	Broken up 1908
Triumph		August 1868	September 1870	April 1873	Broken up 1921

Three more central battery ironclads fell into this group of ships in terms of design, even though they entered service after 1875, the end of the period

covered in this volume. *Alexandra* was an improved version of *Sultan*, with a lower central battery protected by up to 12in of armour, which ran the whole length of the ship, reducing to 6in fore and aft. She carried six 10in RMLs in her lower battery, with two more providing end-on fire from its forward corners. Each side of the upper battery had an 11in gun in its forward corner and a 10in one facing aft. The need to recess these upper-deck guns reduced the width of the upper deck. *Alexandra* was the first ship in the 'Black Battlefleet' to mount vertical compound engines – a significant step forward in terms of marine propulsion, giving *Alexandra* a top speed in excess of 15 knots. The ship was also the last pure central battery ironclad to join the 'Black Battlefleet'.

The firing of a 10in RML on board HMS *Alexandra*. These 18-ton guns fired a shell weighing 400lb (181.4kg), which had to be loaded using a system of overhead winches and rammers. At 1,000 yards, this gun's shells could pierce up to 9in of unbacked wrought iron.

Alexandra Class	
Type	central battery ironclad (one in class)
Displacement	9,492 tons
Dimensions	length 325ft (99.06m) between perpendiculars, 344ft (104.85m) overall; beam 63ft 10in (19.46m); draught 26ft 3in (8m)
Propulsion	Two shafts, powered by two Humphreys two cylinder vertical inverted compound steam engines and 12 boilers, generating 8,498ihp
Maximum speed	15.1 knots
Coal bunkerage	500 tons
Armour	belt: 12in iron, reducing to 6in at extremities, with 10–12in wood backing; bulkheads: 5–8in iron; main battery: 12in iron; upper battery: 8in iron; deck: 1–1.5in iron
Armament	two 11in RMLs, ten 10in RMLs, six 20-pdr BLs (saluting guns), four torpedo carriages
Complement	674

Ship	**Builder**	**Laid Down**	**Launched**	**Completed**	**Fate**
Alexandra	Chatham Dockyard	March 1873	April 1875	January 1877	Broken up 1908

Temeraire Class	
Type	central battery ironclad (one in class)
Displacement	8,540 tons
Dimensions	length 285ft (86.87m) between perpendiculars; beam 62ft (18.9m); draught 27ft (8.23m)
Propulsion	Two shafts, powered by two Humphreys & Tennant two cylinder vertical inverted compound steam engines and 12 boilers, generating 7,697ihp
Maximum speed	14.6 knots
Coal bunkerage	400 tons
Armour	belt: 11in iron, reducing to 5.5in at extremities, with 10–12in wood backing; bulkheads: 5–8in iron; battery: 8in iron; barbettes: 8–10in iron; deck: 1–1.5in iron
Armament	four 11in RMLs, four 10in RMLs, four 20-pdr BLs (saluting guns), two torpedo launchers
Complement	580

Ship	**Builder**	**Laid Down**	**Launched**	**Completed**	**Fate**
Temeraire	Chatham Dockyard	August 1873	May 1876	August 1877	Broken up 1921

Temeraire, designed by Reed's successor Nathanial Barnaby, was a real hybrid. In theory she was a central battery ironclad, with four 10in RMLs firing from broadside ports, and two 11in RMLs in corner ports providing end-on fire. A second pair of 11in RMLs, though, were mounted on the upper deck, one forward, one aft, in what would traditionally be the bow

and stern chase positions. These sat inside open-topped circular barbettes protected by 10in of armour, while the guns themselves were mounted on Moncrieff disappearing carriages. These were raised to fire, but could be lowered below the lip of the barbette for reloading. *Temeraire* was the first barbette ship in British service, and with her heavy armament and thick armour she was a powerful addition to the fleet.

Finally, there was *Superb*, designed by Sir Edward Reed for the Turkish Navy, and built in the Thames Ironworks in Blackwall. She began life as *Hamidieh*, and was essentially a slightly larger version of the British Hercules class. She was completed in 1877, but before she could be delivered the Russo–Turkish War (1877–78) broke out, and under its neutrality obligations the British government was forced to detain the ship. She was duly purchased from the Turks in February 1878, and after extensive alterations she finally entered service with the Royal Navy in 1880 as HMS *Superb*. While *Superb* joined the fleet after the end of the period covered by this volume, in terms of design her place is with the earlier ironclads of the 'Black Battlefleet.'

Superb Class	
Type	central battery ironclad (one in class)
Displacement	9,710 tons
Dimensions	length 332ft 4in (101.3m) between perpendiculars; beam 59ft (17.98m); draught 25ft 6in (7.77m)
Propulsion	single shaft, powered by a Maudslay two cylinder horizontal direct acting steam engine and nine boilers, generating 6,580ihp
Maximum speed	13.2 knots
Coal bunkerage	600 tons
Armour	belt: 12in iron, reducing to 7in at extremities, with 8–12in wood backing; bulkheads: 10in iron; battery: 12in iron; conning tower: 8in iron; deck: 1.5in iron
Armament	16 10in RMLs, four 14in torpedo launchers
Complement	654

Ship	**Builder**	**Laid Down**	**Launched**	**Completed**	**Fate**
Superb (ex-*Hamidieh*)	Thames Iron Works, Bow	March 1873	November 1875	November 1880	Broken up 1906

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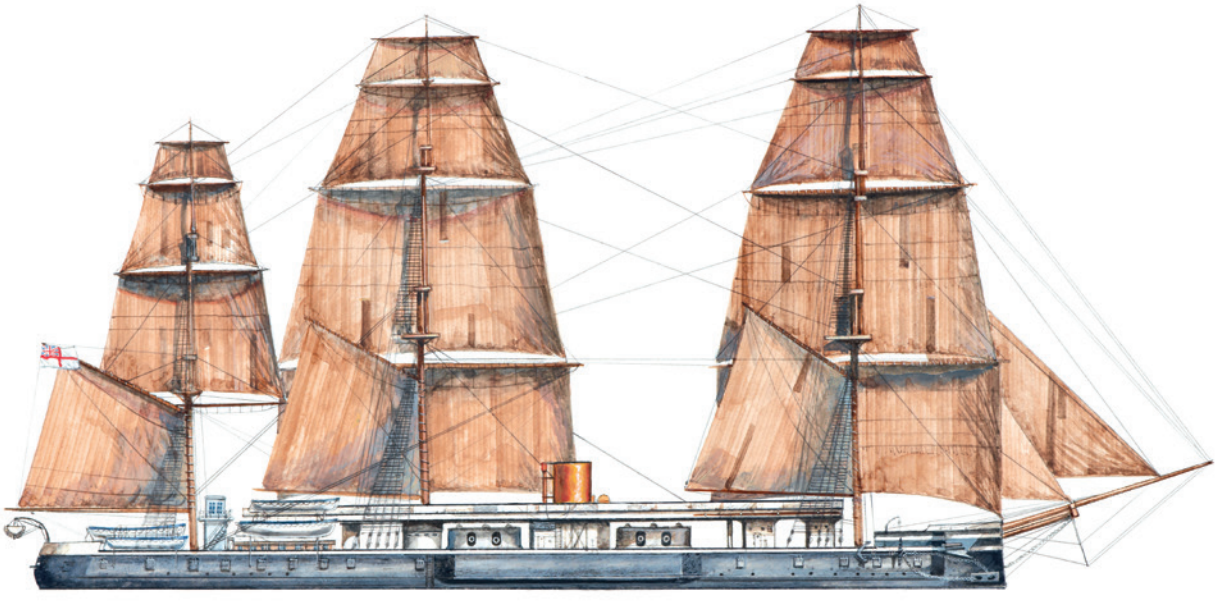
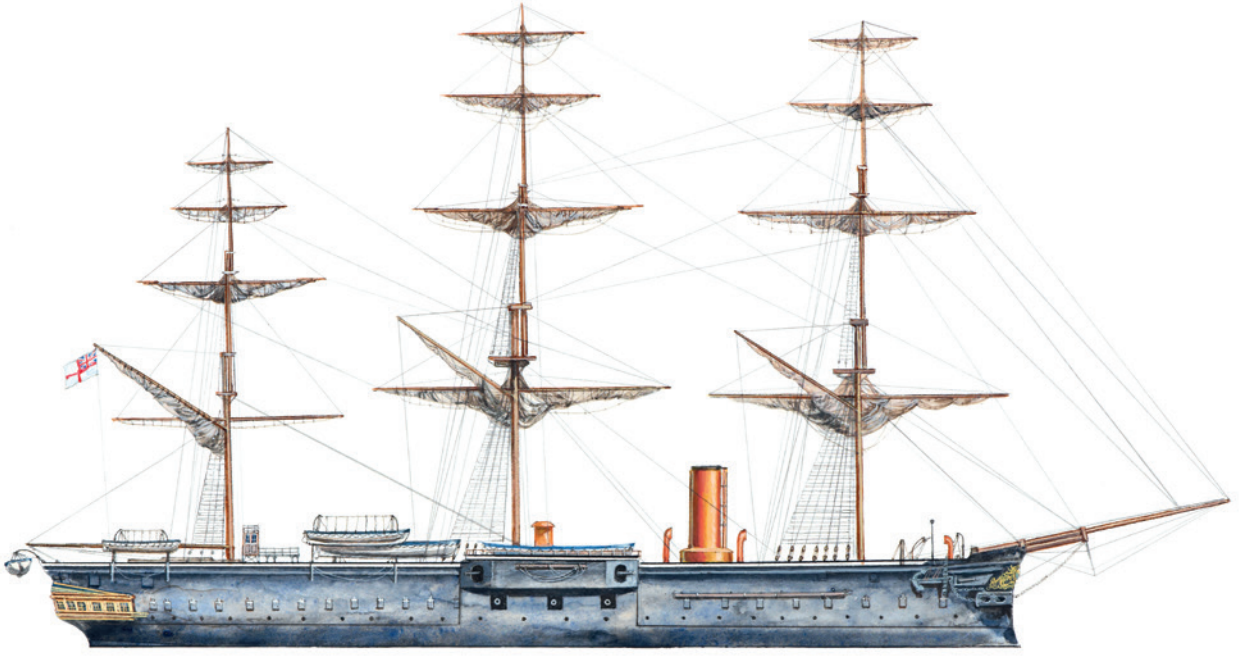
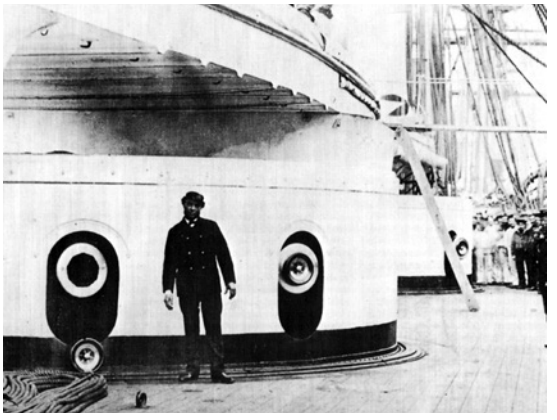
HMS *MONARCH* & HMS *VANGUARD*, 1871

While the *Warrior* represented a major revolution in warship design, it was the development of the gun turret that represented the next quantum leap in naval architecture. After building a number of small coastal defence turret ships, the Admiralty ordered the construction of two ocean-going versions – the *Captain* and the *Monarch*. When *Monarch* entered service in 1869 she was the fastest ironclad in the fleet, and proved a reliable and successful warship. Her steam-powered turrets each carried a pair of 12in 25-ton RMLs, which proved as effective as the ship in which they were mounted. The only real drawback of *Monarch*'s design was her inability to train her guns fore and aft owing to her masts, rigging and superstructure. For the most part, she served in the Channel Fleet, remaining in active service until 1902.

While the four smaller central battery ironclads of the Audacious class were far less impressive, they were destined to fulfil a very different role. While *Monarch* (top) became the most powerful ship in the Channel Fleet, *Vanguard* (bottom) and her three sister ships of the Audacious class were built for service overseas, and rated as Second Class Ironclads. Despite this limited design objective, they were innovative, being the first British ironclads to mount their ordnance on two decks, within the protective confines of their armoured casemate. Only the protruding upper battery contained embrasures, allowing two of the 9in RMLs on each beam to train fore and aft. They were also twin-screwed, the first large ironclads of the 'Black Battlefleet' to carry two engines rather than one. Rather than serving overseas, *Vanguard* remained in home waters until she was accidentally rammed and sunk by her sister ship *Iron Duke* in 1875.







Captain Cowper Coles, standing in front of one of the gun turrets of HMS *Monarch*. He was critical of her design, and as a result the Admiralty allowed Coles to produce another masted turret ship to his own specifications. He was drowned when this ship, the *Captain*, foundered off Cape Finisterre in the autumn of 1870.

Turret ships

Throughout the 1860s naval architects, the Admiralty and even the British press all hotly debated the future of ironclad design. It was clear that the steady increase in both gun size and armour thickness meant that ships were by necessity going to carry fewer but heavier guns, while being protected by increasingly thick armoured belts. This led to the development of the central battery ironclad and attempts to increase the guns' field of fire. Captain Cowper Coles, a naval officer and inventor, proposed a solution of mounting a pair of the largest guns inside a revolving turret. Reed argued that on a fully rigged warship the masts and rigging would severely restrict the turret's field of fire.

While John Ericsson, designer of the USS *Monitor*, is often assumed to have invented the revolving gun turret, in fact Coles not only developed the idea independently, but also patented it before Ericsson did. The two designs were subtly different. While Ericsson's turret revolved on a central spindle, Coles' version was more mechanically practical, as it rotated using rollers. Coles aggressively lobbied the Admiralty, and so in 1865 a turret ship was ordered, based on plans drawn up by Admiralty designers, and supervised at a distance by Reed, who considered himself ambivalent about the project.

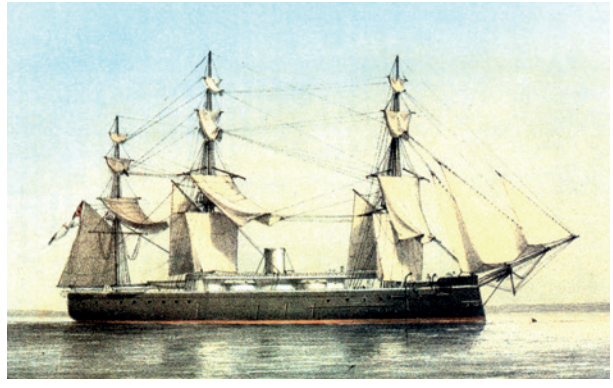
Monarch Class	
Type	masted turret ship (one in class)
Displacement	8,322 tons
Dimensions	length 330ft (100.58m) between perpendiculars; beam 57ft 6in (17.53m); draught 24ft 3in (7.39m)
Propulsion	single shaft, powered by a Humphreys & Tennant two cylinder horizontal return connecting rod steam engine and nine boilers, generating 7,842ihp
Maximum speed	14.9 knots
Coal bunkerage	600 tons
Armour	belt: 7in iron, reducing to 4.5in at extremities, with 10–12in wood backing; bulkheads: 4–4.5in iron; turrets: 8–10in iron; conning tower: 8in iron
Armament	four 12in RMLs in two twin turrets, three 7in RMLs
Complement	575

Ship	Builder	Laid Down	Launched	Completed	Fate
Monarch	Chatham Dockyard	June 1866	May 1868	June 1869	Broken up 1905

The result was the *Monarch*, a masted turret ship of 8,322 tons. Her two turrets were mounted on the upper deck, fore and aft of her funnel, and inside each were two 12in RMLs. The bulwark in front of the turrets flipped down to allow the guns to fire. Both turrets were protected by thick armour, while the loading areas below them were also shielded by an armoured box. This strange ship carried a full sailing rig, and a flying deck over the top of the turrets kept most of the rigging away from the turrets. The ship was difficult to handle, but she was well designed and seaworthy.

Coles was unimpressed. He was extremely critical of the *Monarch*'s design, and even before she was laid down he began lobbying the Admiralty to build another turret ship to his own specifications. He was supported by

OPPOSITE
HMS *Captain* had her turrets placed low in the ship to improve her stability. Unfortunately this also reduced her freeboard, a factor which may well have played a part in her loss in September 1870, just five months after she was first commissioned.



the press, and in late 1866 the Admiralty acquiesced. Coles' ship was laid down in early 1867, and entered service three years later, just six months after *Monarch* was commissioned. Coles' ship, the *Captain*, was also a masted turret ship, and at first glance looked similar to *Monarch*. Although marginally smaller in size and displacement, she was fully rigged and carried two twin turrets, each mounting 12in RMLs. There the similarities ended. While *Monarch* mounted her turrets on her main deck, *Captain* carried hers a deck lower, which meant the ship had a freeboard of just 6.5ft (2m).

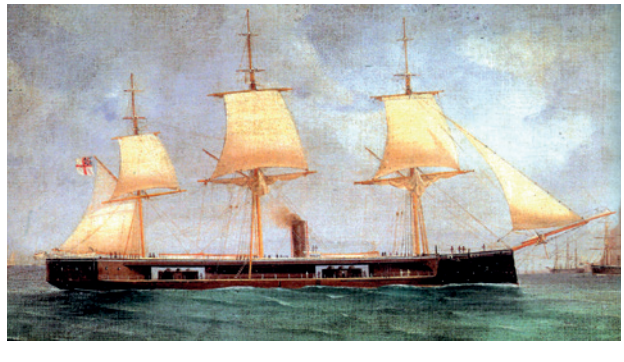
Captain Class	
Type	masted turret ship (one in class)
Displacement	7,767 tons
Dimensions	length 320ft (97.54m) between perpendiculars; beam 53ft 3in (16.23m); draught 24ft 10in (7.57m)
Propulsion	Two shafts, powered by two Lairds four-cylinder horizontal trunk steam engines and eight boilers, generating 5,400ihp
Maximum speed	15.2 knots
Coal bunkerage	600 tons
Armour	belt: 8in iron, reducing to 4in at extremities, with 7in wood backing; bulkheads: 7in iron; turrets: 9–10in iron; conning tower: 7in iron
Armament	four 12in RMLs in two twin turrets, two 7in RMLs
Complement	500

Ship	Builder	Laid Down	Launched	Completed	Fate
Captain	Lairds, Birkenhead	January 1867	March 1869	January 1870	Foundered, September 1870

ABOVE LEFT
HMS *Monarch* was designed with a full sailing rig, but in 1872, in the wake of the *Captain* disaster, she was given the barque-rig seen here to improve her stability under sail. She was known as a fast ship though, and when she first entered service she was the fastest ironclad in the fleet under steam.

ABOVE RIGHT
Unlike the ill-fated *Captain*, the gun turrets of HMS *Monarch* were mounted on her main deck, well above the waterline. This proved to be a better design. She was the first British turret ship, and also the first warship in the fleet, to carry 12in guns. She was generally regarded as a successful ship, and was a fast vessel, both under steam or sail.

Once *Captain* entered service it was found she was top-heavy, and there were concerns about her stability. Just a few months later, in September 1870, *Captain* foundered during a gale in the Bay of Biscay. Cowper Coles was on board her when she sank in a tragedy that claimed 472 lives. This disaster forced the Admiralty to reconsider its policy of ironclad design. By then Reed had resigned following a series of heated clashes with Coles. However, he had already participated in the design of several small coastal defence



The design of HMS *Devastation* was a major departure from all previous ships. She had a very low freeboard fore and aft, with a higher freeboard amidships. This view shows her from the stern, where the upper deck was recessed immediately behind the turret, giving her a strangely bulbous appearance.

monitors, which were viewed as highly successful. He also produced plans for a mastless turret ship, whose guns would have an almost all-round field of fire.

In early 1869, Reed submitted these plans to the Admiralty. His design was based on those he produced for his small coastal defence monitor *Cerberus*, only developed on a much larger scale. The lack of masts and spars led to widespread criticism, but Reed stood his ground. As ironclads became heavier their performance under sail was becoming poorer, while engines had become far more reliable. Reed's design was eventually approved, and the two ships of the Devastation class were laid down in July and November 1869. Unfortunately, Reed's feud with Cole led to his resignation the following year, so he was unable to see his project through to completion. His successor Nathaniel Barnaby reviewed the plans while the ships were being built and made some modifications, raising their freeboard by a deck, apart from at the bow and stern. *Devastation* was completed in early 1873, and *Thunderer* followed four years later.

Devastation Class	
Type	turret ship (two in class)
Displacement	9,330 tons
Dimensions	length 285ft (86.87m) between perpendiculars, 307ft (93.57m) overall; beam 62ft 3in (18.97m); draught 26ft 8in (8.03m)
Propulsion	Two shafts, powered by two Penn horizontal trunk steam engines (*Thunderer* Humphreys & Tennant horizontal direct acting steam engines) and eight boilers, generating 6,640ihp (*Thunderer* 6,270ihp)
Maximum speed	*Devastation* 13.8 knots *Thunderer* 13.4 knots
Coal bunkerage	*Devastation* 1,800 tons *Thunderer* 1,600 tons
Armour	belt: 12in iron, reducing to 8.5in at extremities, with 16–18in wood backing; bulkheads: 5–6in iron; turrets: 10–14in iron; breastwork: 10–12in iron; conning tower: 6–9in iron; deck: 2–3in iron
Armament	four 12in RMLs in two twin turrets
Complement	358

Ship	Builder	Laid Down	Launched	Completed	Fate
Devastation	Portsmouth Dockyard	November 1869	July 1871	April 1873	Broken up 1908
Thunderer	Portsmouth Dockyard	June 1869	March 1872	May 1877	Broken up 1909

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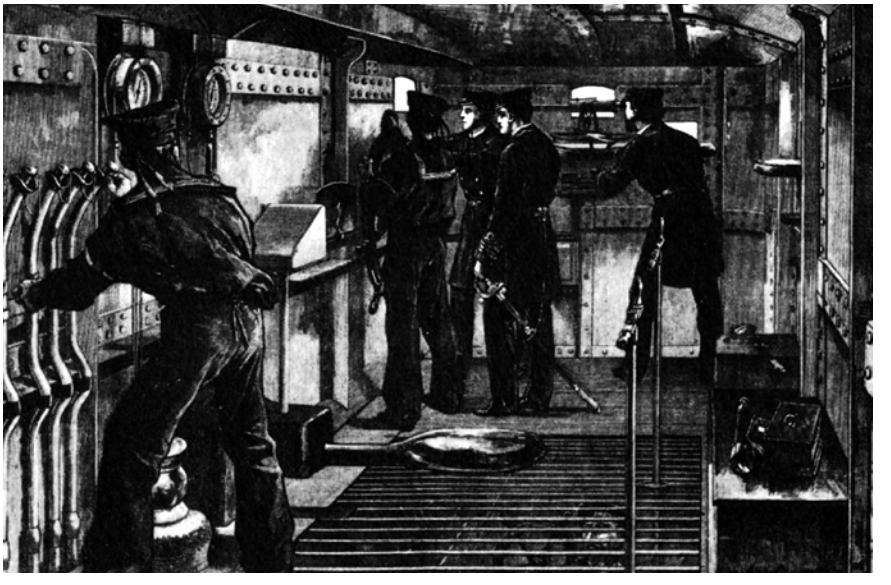
HMS *CAPTAIN* IN THE BAY OF BISCAY, 1870

Following the success of the turreted ironclad during the American Civil War (1861–65), the Admiralty came under increasing pressure to develop turret ships of its own. One of the greatest advocates of the turreted ironclad was Captain Cowper Coles, whose criticism of the design of the *Monarch* led to the Admiralty acceding to public pressure and inviting him to design his own vessel. The result was the *Captain*, which superficially resembled the *Monarch*, but which differed from it in several key areas. The most obvious difference was the placement of her two twin-gun turrets on a deck lower than in the earlier ironclad. She was also twin-screwed, giving her an impressive top speed of more than 15 knots, but her sailing qualities were less favourable. Many felt the ship carried too much weight, which in turn reduced her already low freeboard more than Coles had anticipated. Just eight months after she entered service she encountered a gale in the Bay of Biscay and began heeling alarmingly. Shortly after midnight on 7 September she foundered, taking Coles and 472 men down with her. There were only 18 survivors. One of those lost was a midshipman, the son of the First Lord of the Admiralty, who had ordered the boy to sail in her to show the Admiralty's confidence in Coles' design.



The interior of the armoured conning tower of the mastless turret ship HMS *Thunderer*. In theory the ship could be manoeuvred and fought from within this small protected box, but visibility was limited, and during manoeuvres most captains preferred to control their ship from the open bridge.

Commissioning of the 'Black Battlefleet', 1860–75

1861	October	*Warrior*
	December	*Defence*
1862	July	*Black Prince*
	September	*Resistance*
1863	April	*Royal Oak*
1864	February	*Hector*
	April	*Prince Consort*
	November	*Achilles*
1865	July	*Caledonia*
		Ocean
1866	April	*Bellerophon*
	June	*Lord Clyde*
	October	*Zealous*
1867	March	*Royal Alfred*
	June	*Agincourt*
	August	*Lord Warden*
1868	September	*Valiant*
	October	*Northumberland*
	November	*Hercules*
	December	*Minotaur*
1869	June	*Monarch*
1870	January	*Captain*
		Repulse
	September	*Audacious*
		Vanguard
	October	*Invincible*
1871	January	*Iron Duke*
	October	*Sultan*
1872	June	*Swiftsure*
1873	April	*Triumph*
		Devastation

After the *Captain* disaster these new and unusual-looking ships were viewed with suspicion, but they proved stable, reliable and completely seaworthy. The real success of their design, though, was that *Devastation* and *Thunderer* marked the start of a new era in naval construction. Gone were the masts and sails that had remained as a relic of the old sailing navy. Gone too were the mounting of guns in batteries. While *Monarch* and *Captain* had shown the way, it was *Devastation* that truly established the gun turret as the ideal mount for naval ordnance. This new ship was no longer even a proper ironclad. With her 12in armoured belt and powerful armament of 12in guns, she was a new breed of warship entirely – the world's first battleship.

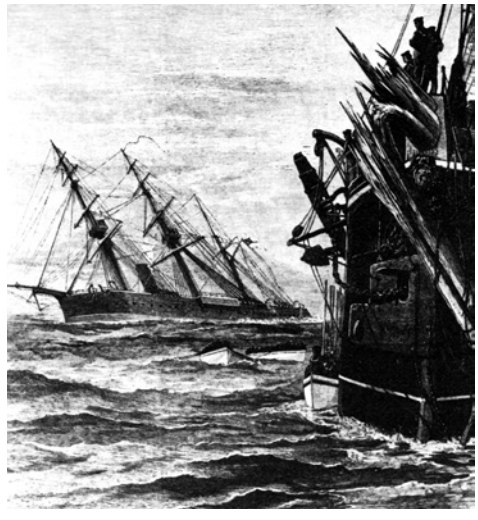
TACTICAL REQUIREMENTS

The advent of steam did little to alter tactical doctrine in the Royal Navy. Warships were expected to use their sails to conserve coal, but in action they would use their engines. Sails were furled and topmasts were struck down to reduce vulnerability to enemy fire. Freedom from the wind meant the ship could effectively steam where it wanted, or it might do were it not for the constraints of operating as part of a squadron. Unlike the small ironclads built by both sides during the American Civil War, these British ironclads were seagoing vessels, mounting powerful broadside batteries. They were designed to fight in fleet actions rather than to act alone. In other words, despite the move from sail to steam, early British ironclads were built to fight in much the same way as their sail-powered forebears.

Beyond that, the Admiralty had given little thought to the way its new ironclads would be fought. These ships were among the fastest in the world under steam, but unless they were pursuing a fleeing enemy this was considered less important than the ability to form and maintain a line of battle. These were still broadside-armed ships, so

forming a battle-line made sense. That said, it was a time of near-constant technological change, and the Admiralty was unable to incorporate adequate tactical guidelines in its specifications to ship designers. Instead, it was forced to react to new technological developments or to reports of actions from overseas. So, during this period Britain's warships never fulfilled a properly developed tactical role.

For example, at the battle of Lissa (1866) the Austro-Hungarian fleet defeated its Italian opponents by using ramming tactics to overcome their enemy's advantage in firepower. Subsequently, the Admiralty deemed it expedient to give all future ironclads a ramming capability: the three ships of the Minotaur class, completed after Lissa, were all given a substantial ram. The Audacious class also had effective rams – so much so that when *Iron Duke* accidentally rammed *Vanguard* in 1875, she inflicted a mortal wound on her sister ship. Although by then the increasing power of naval ordnance had effectively made ramming tactics almost too dangerous to contemplate, British ironclads continued to be fitted with them, just in case.



HMS *Vanguard*, sinking in the Irish Sea off Dublin, after being accidentally rammed in fog by her sister ship *Iron Duke* in September 1875. The armoured bow of the *Iron Duke* sliced through the outer hull below the *Vanguard*'s armoured belt, flooding her boiler and engine rooms. She took almost 90 minutes to sink, allowing sufficient time for the entire crew to abandon ship.

The switch from a broadside to a central battery design from 1866 on did little to alter tactical doctrine. After all, these changes reflected the way guns were arranged and protected, not the way the ships were expected to fight. Even the idea of mounting guns in a central battery ironclad so that they could provide end-on fire merely replicated the capability of bow or stern chasers. *Warrior* already had that capability, but she was still primarily a broadside warship, and would fight in the same manner as one of Nelson's ships-of-the-line. Even masted turret ships failed to change this tactical arrangement – the superstructure and rigging prevented the gun turrets from firing on targets much beyond the beam of the ship.

This all changed with the arrival of *Devastation*. Here at last was a British ironclad capable of firing her guns ahead and astern, as well as to either beam. The revolutionary tactical ramifications of this were still not apparent when she was commissioned in 1873. So throughout the 15 years covered by this book, the British plan – such as it was – was simply to form the 'Black Battlefleet' into a battle-line and to pound at the enemy, broadside to broadside. Even then, the business of signalling within a fleet had barely advanced since the Napoleonic Wars, so more complicated manoeuvres were generally seen as beyond the ability of a fleet commander to control. These ships were faster, vastly more powerful and mechanically more capable than anything which had come before them. They should have been capable of dictating the pace of a sea battle. However, the way the Royal Navy planned to fight them would still have been perfectly understood by Nelson. Change would be foisted on the service only by the launch of yet more turretless ships and the continuing trends towards fewer but larger guns.

The design of the Devastation class of turret ships was truly revolutionary, but when the ships entered service they were viewed with suspicion by public and sailors alike. *Devastation*, here, soon won the approval of her crew, as she proved both stable and reliable.

ARMOUR

What defined these warships and gave them their collective name was the protective iron armour they carried, designed to render them near-impervious to enemy fire. The idea behind this derived from the armour-clad French floating batteries that saw action during the Crimean War. These proved their effectiveness in action, but while they were well protected, they were floating gun positions rather than warships, with only enough motive power to move them into position. What they demonstrated, though, was that iron plate could be used to protect the hull of a warship. This next step was also made by the French, when in 1858 they created the world's first ironclad warship. *La Gloire* was a wooden-hulled warship, clad in iron plate. Numerous laminated sheets of wrought-iron with a combined thickness of 4.7in (12cm) were bolted to the outside of her wooden hull, which was already 17in (43cm) thick. The result was a quickly produced and reasonably effective 'iron-clad' warship – the first of her kind.

The British reaction has already been discussed, but effectively it resulted in the commissioning of their own ironclad warships. While the British were slow to understand the importance of the threat posed by the French ironclad, their response when it came was thoroughly effective. Between the time *La Gloire* was laid down in the spring of 1858 and its launch 20 months later, the Admiralty had accepted the need to build ironclads of its own, answered the design questions this raised and begun the process of transforming the British fleet. That the Admiralty was able to do this so quickly and effectively was thanks to the country's status as the world's leading industrial power.

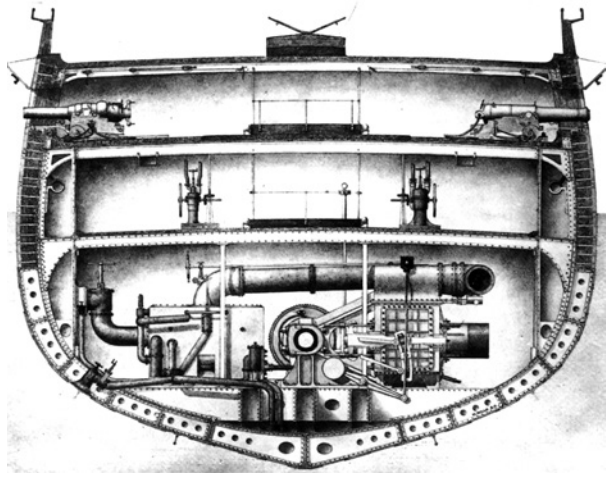
Warrior was to be built with a wrought-iron hull, and the same material was selected for her armour. Cast iron was too hard and brittle to be used as a form of protection – experiments showed it would shatter when fired upon. Wrought iron was more malleable, and further testing revealed a 4in-thick plate of it could stop the penetration of the largest guns carried in either the British or French navies at the time. The ability to produce rolled iron was still not available. This involved the stacking of thinner plates together, heating them to a high temperature and then passing them between huge iron rollers to produce a single plate of metal. This technique would become available from the late 1860s onwards. For *Warrior* though, the only available method was the 'pudding process', where liquid metal was poured into a mould, to produce sheets up to 0.5in (12mm) thick. These

BELOW LEFT
The hull of HMS *Warrior* was formed from relatively thin layers of wrought iron. However, attached to its outer surface were two layers of teak, both 9in thick, one with the wood laid vertically and the other horizontally. Bolted to this was an outer protective layer of 4.5in of wrought-iron plate, pierced by the ship's row of gun ports and a small number of portholes. It is this outer layer of armour that is seen here.

BELOW RIGHT
HMS *Warrior* had an oval-shaped armoured rifle tower sited between her main and mizzen masts. She was commanded and conned from two flying bridges – the forward one shown here, sited between her funnels, and an after bridge, located just forward of the conning tower and wheel. While the after bridge was the main one, the forward bridge provided a better vantage point during certain manoeuvres, such as coming alongside or mooring ship.

were then stacked together, along with iron bars, and the stack was heated to just short of melting point, before being flattened using 4-ton steam hammers. The result was a single sheet of wrought iron that, while not as strong as a rolled sheet, was still much more resilient than its French-manufactured counterpart.

Each of these plates was 15ft (4.5m) long, 3ft (1m) wide and 4.5in. (11.4cm) deep. On the outer side of the *Warrior*'s iron hull, two 9in (22.5cm) layers of teak had been attached, one running horizontally, the other laterally. The iron plates were secured to this backing using longitudinal iron frames, supported by transverse plates. The plates themselves had tongue and groove connections at each end, so that each plate would support those next to it, to provide additional strength. The plates were bolted to these supports, which in turn spanned the thickness of the two-layered wooden backing to create a protective shell for the hull. In *Warrior*, this shell did not run the whole length of the ship. Instead it formed a box which encompassed most of the gun deck and was closed at both ends by transverse iron bulkheads. The resulting armoured box was pierced by gun ports – 13 per side – and by two entranceways in each bulkhead. In effect then, *Warrior* was only partially armoured.



This cross-section of HMS *Warrior*'s decks shows how the outer hull below the waterline consisted of a double bottom, the two iron skins separated by the perforated transverse floor plates. The engines and boilers sat on a box girder support seen here. Above this came the belt armour, of iron backed by teak. Each wooden deck (upper, main and lower) was supported by iron frames.

Later, the great Victorian naval constructor Edward Reed said of the design that it was, 'a highly skilled and scientific construction, carefully designed with a view to the objects which had to be accomplished'. This said, there were flaws in the design. First, the unprotected parts of the ship included the steering gear, which was therefore vulnerable to enemy fire. This was rectified before the next batch of ironclads was launched, as the armoured box was extended to encompass the whole upper deck or gun deck of the ships which followed. Also, it was found that the tongue and groove support for the plates would transmit the force of a hit to other adjoining plates, and therefore increase the risk of damage to the armour. This was therefore dropped before the Hector-class ships were completed. Finally, rather than lying proud of the armour plate, the bolts securing it to the hull were made from hardened steel, to make them stronger, and countersunk into the plates, to make them less vulnerable to shearing in the event of a direct hit on them.

Despite these faults, it was still a superb design, and led to the production of an ironclad which was far better protected than its French counterpart, thanks to the better quality of its wrought-iron plating. This was demonstrated by firing tests which showed that shot and shell fired from British 68-pdr smoothbore guns penetrated mock-ups of *La Gloire*'s armour, exploding either in the wooden backing or penetrating beyond it. By contrast, the same rounds failed to breach a mock-up of *Warrior*'s armour, even at ranges as short as 200 yards.

The majority of the ordnance on the main gun deck of HMS *Warrior* were 68-pdr smoothbore muzzle-loading guns (SBs), 13 on each side, as well as five 110-pdr RBLs. By 1867 these smoothbores had been replaced by 7in rifled muzzle-loading pieces (RMLs).

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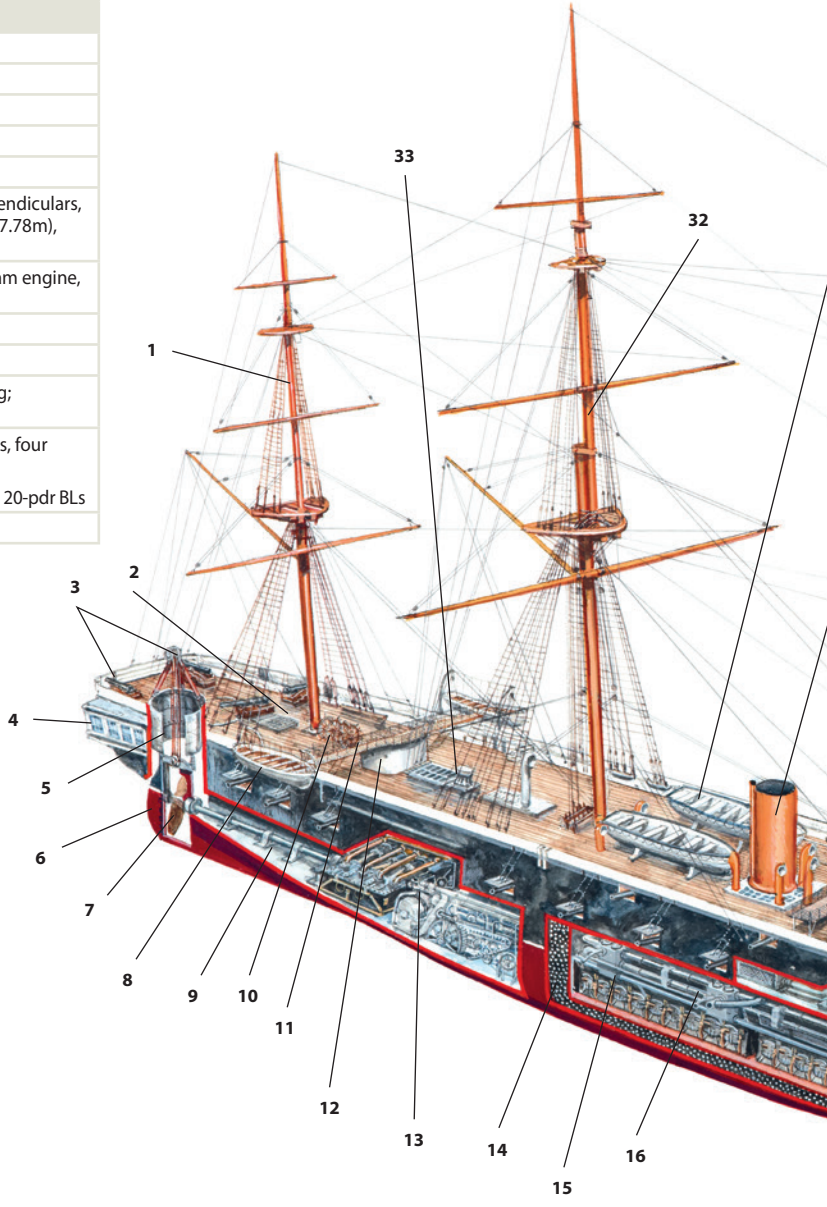
HMS *WARRIOR*, *c.*1862

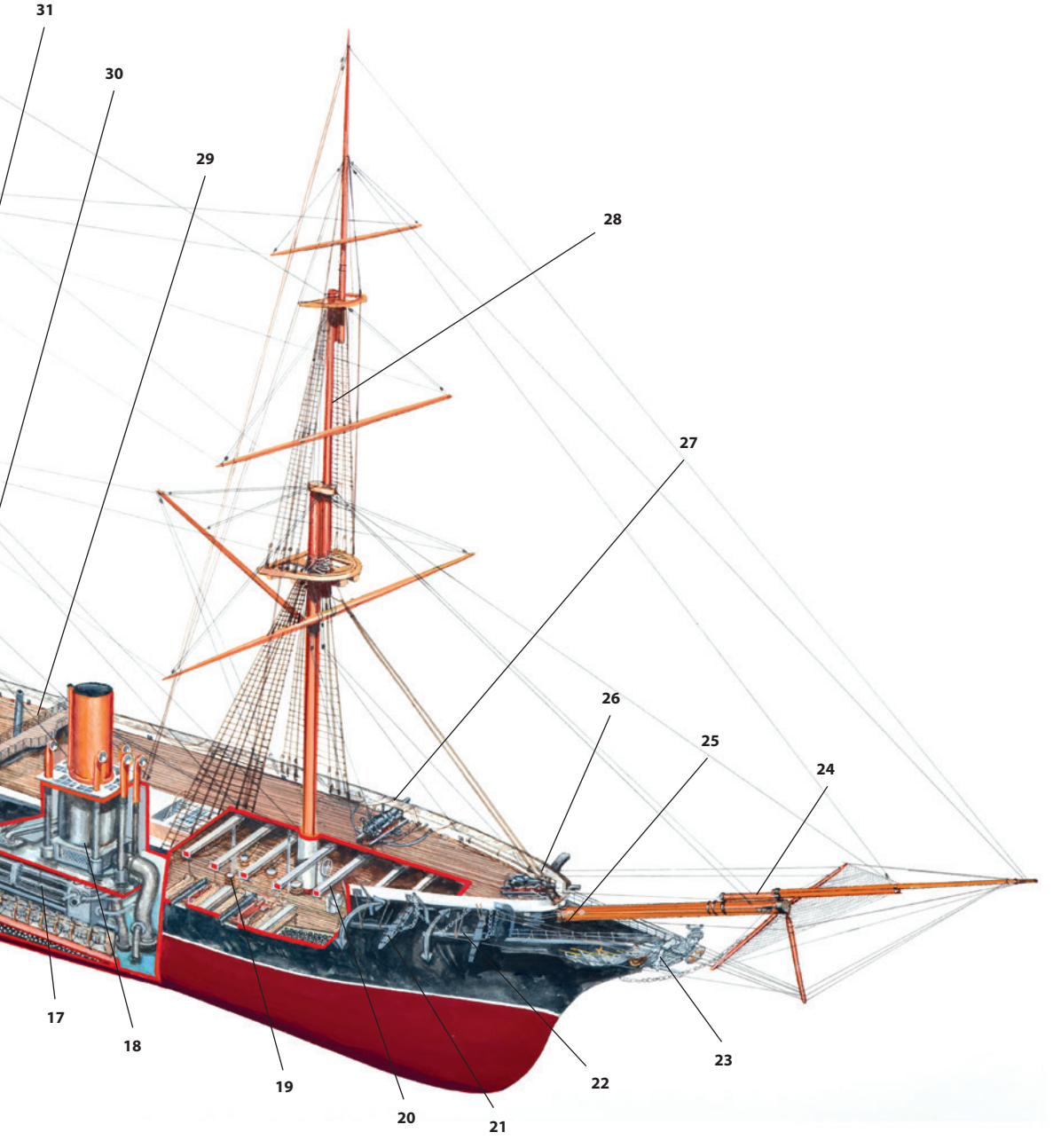
The *Warrior* was a warship unlike any that had gone before. She was iron-hulled, but her sides – or rather the main parts of them – were protected by an armoured layer backed by two layers of teak. This effectively made her impervious to enemy shot, while her own powerful broadside armament gave her an enviable level of firepower. Unlike the French *Gloire,* she was a large ocean-going ship, designed to serve wherever in the world she was needed. In fact she spent much of her active career in home waters, serving with the Channel Fleet. She was rearmed during her career, and underwent a number of refits and even reclassifications before being placed in reserve in 1875. By 1892 she had been downgraded from a 'battleship, third class' to an 'armoured cruiser'. She would later languish as a storage hulk and even a floating pontoon before being rescued, lovingly restored and turned into the floating museum ship that now dominates the entrance to Portsmouth Historic Dockyard.

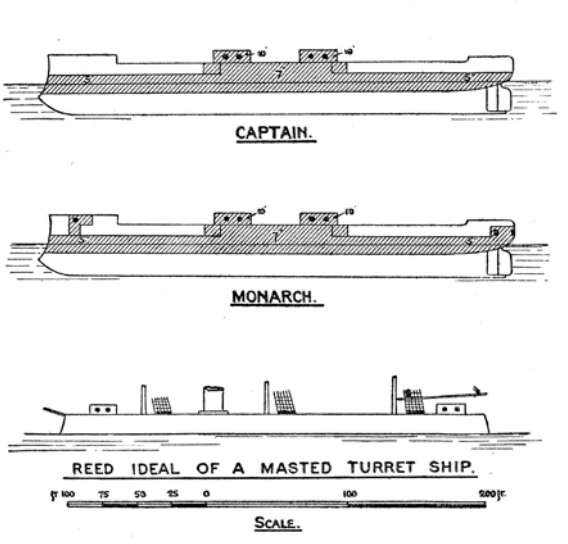
Warrior-class broadside ironclad specifications	
Builder	Ditchburn & Mare, Blackwall, London
Laid Down	May 1859
Launched	December 1860
Completed	October 1861
Displacement	9,137 tons
Dimensions	length 380ft (115.87m) between perpendiculars, 420ft (128m) overall, beam: 58ft 4in (17.78m), draught: 26ft (7.92m)
Propulsion	single shaft Penn horizontal trunk steam engine, and ten boilers, generating 5,267ihp
Maximum speed	14.1 knots
Coal bunkerage	850 tons
Armour	belt: 4.5in iron with 18in wood backing; bulkheads: 4.5in iron
Armament	(1861): ten 100-pdr RBLs, 26 68-pdr SBs, four 70-pdr BLs (1867): four 8in RMLs, 28 7in RMLs, four 20-pdr BLs
Complement	707



KEY

1. Mizzen mast
2. Quarterdeck
3. 110-pdr RBL (stern chaser - shown twice, once in each of its stern chase positions)
4. Stern gallery
5. Propeller lifting tunnel
6. Rudder
7. Propeller
8. Ship's gig (ship's cutter on port side)
9. Propeller shaft passage
10. Ship's wheel and steering position (wheel repeated below decks)
11. After flying bridge
12. Rifle tower
13. Main machinery space
14. Coal bunker (starboard)
15. Auxiliary machinery space
16. After stoke hold
17. Forward stoke hold
18. Funnel hoisting mechanism (one for each funnel)
19. Main gun deck
20. Animal pen
21. Sheet anchor (one of two)
22. Bower anchor (one of two)
23. Figurehead
24. Bowsprit
25. Heads (toilets)
26. 110-pdr RBL (bow chaser)
27. 40-pdr BL (saluting gun - one of four)
28. Foremast
29. Forward flying bridge
30. Funnel (one of two)
31. Ship's launches (two)
32. Mainmast
33. Capstan (repeated below deck)





Unlike previous British ironclads, the evolution of the masted turret ship allowed the armoured protection to be concentrated around the turrets and magazines, while lighter protection extended in a belt along the ships' waterlines. At the bottom is a design proposed by Sir Edward Reed, where the turrets were not obstructed by masts and superstructure. This idea eventually developed into his plan for the Devastation class of mastless turret ironclad.

This basic design was repeated with minor variations in all subsequent British broadside ironclads. Even those wooden-hulled steam-powered warships which were adapted into ironclads enjoyed a roughly similar level of protection, as not only was the armoured plate attached directly to the wooden hulls, but the space behind the hull, and between the ship's frames, was reinforced by yet more timber to create a backing that could be as much as 31in (77.5cm) thick. An additional 1.5in (3.7cm) of plate was also attached between the wooden frames and this reinforcing planking, increasing the stopping power of the armour even further.

As gun sizes increased then so too did the thickness of the armoured plate protecting these ships. When he designed *Bellerophon*, Reed added a narrow gap between the outer hull and the wooden backing, spanned by iron stiffeners. Effectively this created a space which might protect the hull if the armour itself was dented by the impact of an enemy shot. In *Hercules*, horizontal iron stiffeners were attached between the layers of wooden backing, effectively creating another means of deflecting the force of an enemy shot if it dented the outer armoured belt. The armoured plate was now 9in thick – twice the width of that in *Warrior*, reducing to 6in towards the bow and stern, away from the ship's more vulnerable spaces. Similarly, the wooden backing was 20in thick, reducing to 10in near the bow and stern. Tests showed that this form of armour was impervious to any projectile then in existence.

By the time *Hercules* was being completed in 1868, rolled iron plate was available, which further increased the protection afforded by the armour. By 1870, sheets as thick as 6in were being manufactured, shaped exactly to fit to a particular place on the ship's side. Armoured bolts were used to attach these plates, and the result was a level of protection which was able to keep pace with the steady increase in both gun size and the penetrating power of these weapons. The same principles that applied to armoured hulls were also in play during the design and construction of armoured turrets. In *Monarch* and *Captain*, turrets consisted of a similar 'sandwich' of iron surface, wooden backing and thick armoured plate. This reached its height in the design for the *Devastation*, whose turrets were protected by 14in of iron plate, backed by wood, interspersed with a second thinner layer of armour, as well as iron stiffeners and then a thick iron inner turret wall.

Between 1860 and 1875 naval architects and gun designers were continually improving the effectiveness of their product, whether it be armoured plate, guns, carriages or engines. If ordnance designers felt they had created a gun capable of penetrating the armour of the latest warship, within a few months naval designers had come up with a solution which rendered their next design of ironclad suitably protected against the destructive power of that new weapon. Certainly by the early 1870s, when the latest generation of 25-ton RMLs firing 11in and 12in shells were entering service, none but the latest ironclads were able to withstand the penetrative effects of their shells. Everything was moving so rapidly that warships were virtually

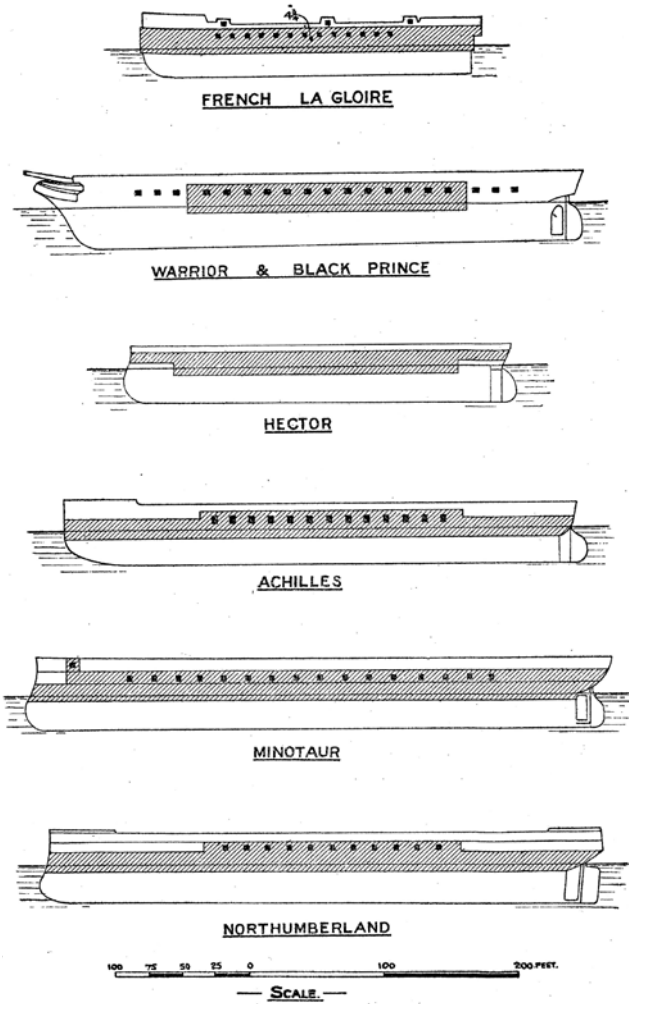
obsolete by the time they entered service, and so the 'Black Battlefleet' was constantly evolving as new, better-armed and protected warships came to the fore, and the warships of just a few year before were relegated to a supporting role. That though, was the cost of maintaining the world's most powerful battlefleet during a time of immense technological change.

ORDNANCE

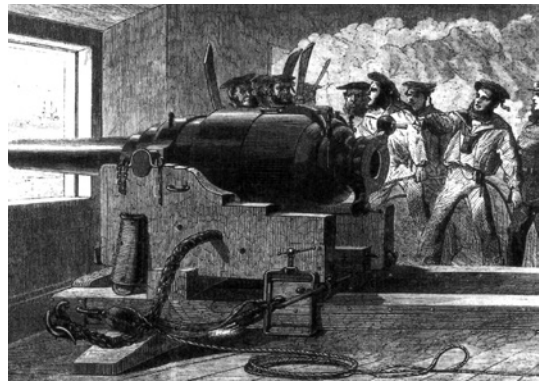
Shell guns

The development of the ironclad also coincided with a revolution in ordnance. Its origins can be traced to 1822, when the French general Henri-Joseph Paixhans first advocated the use of exploding shells in naval combat. It took 15 years before the French adopted his idea, and longer still for the British to follow suit. However, the effectiveness of shellfire against wooden-hulled warships was ably demonstrated at the battle of Sinope (1853), when the Russian Black Sea fleet eviscerated its Turkish opponents. Even then, the adoption of shell guns was slow, so that in 1861, when the steam-powered ship-of-the-line *Victoria* was completed, only half her armament consisted of explosive shell guns. For the *Warrior*, it was felt this gun was the best the navy had with which to counter *La Gloire*, so the bulk of *Warrior*'s ordnance consisted of these powerful weapons.

During this period, the Army's Ordnance Department controlled the design and manufacture of all British ordnance, including those naval guns. The Army classified its shell guns according to their bore – hence the piece designed by the Inspector of Artillery Henry Dundas in 1847 was designated the 8in shell gun. In the Royal Navy though, weapons were traditionally labelled by the weight of their projectile. So, as far as the navy was concerned, this weapon was the 68-pdr. It was a muzzle-loading smoothbore (or SBML) weapon made from cast iron, with a barrel weight of 4.75 tons, able to fire either a solid iron 68lb (30.8kg) roundshot, 56lb (25.4kg) hollow explosive shot or 51lb (23.1kg) shell. It could also fire grapeshot or liquid iron (red-hot shot). This made it a versatile weapon. It had an impressive muzzle velocity of 1,580ft per second (482m per second), and while iron shot fired at a mock-up of *La Gloire*'s hull proved ineffective, it was found that steel shot or shell fired from 500 yards (457.2m) could easily penetrate the French ship's



A comparison of the size, hull shape and armoured belts of the French ironclad *La Gloire* and a selection of British broadside ironclads. Note how the protection afforded to *Warrior* and her sister did not cover all of her main battery. In later British ironclads the belt not only protected the guns, but it was also extended further fore and aft.



ABOVE LEFT
HMS *Warrior* carried two Armstrong 110-pdr rifled breech-loading guns (RBLs) on her upper deck, where they were used as bow and stern chasers. An ingenious arrangements of brass rails and rollers also allowed them to be trained to either side, where the guns could lend their fire to the ship's broadside. This bow chaser could fire out of four gun ports, two on either side of the bowsprit and two on either beam of the ship. This gun, though, is a fibreglass replica.

ABOVE RIGHT
An Armstrong 110-pdr breech-loading rifled gun in action. The engraver has taken a few liberties with the size of the gun port and the height of the deck, but the depiction of the gun itself is reasonably accurate, although the navy of this period favoured wheeled carriages for its RBLs.

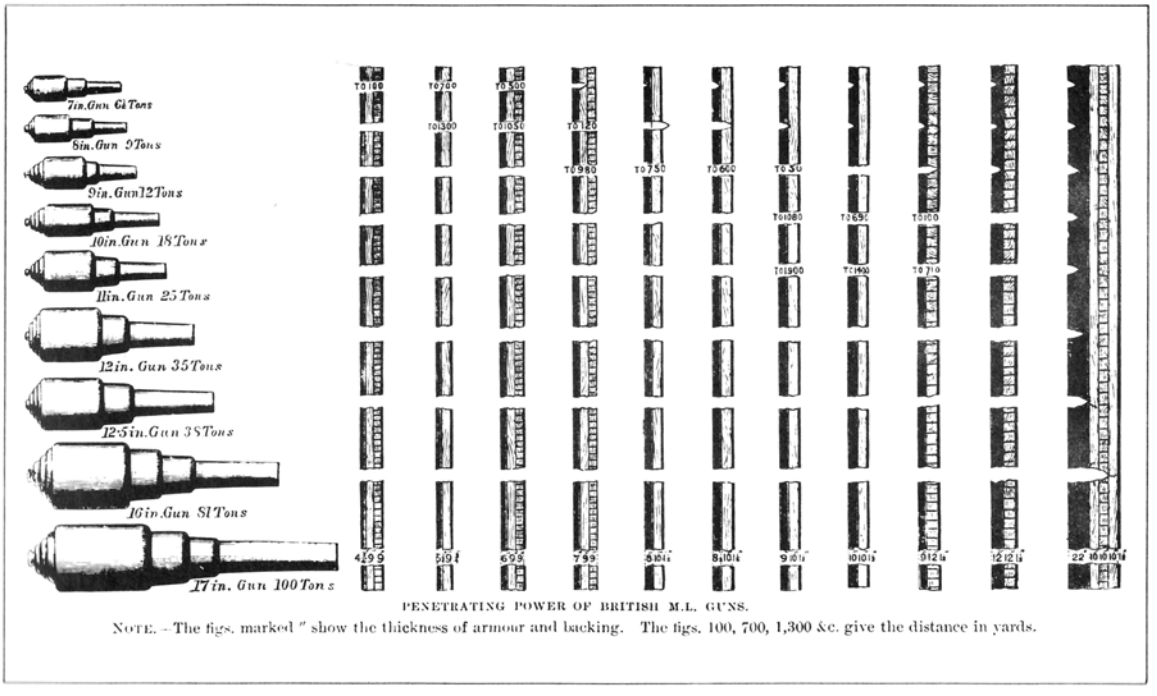
armour, whose protective cladding was less resilient than that of her British counterpart.

In *Warrior*, 13 of these 68-pdr smoothbores were mounted on each broadside. In the middle of the gun deck though, were eight even more novel guns, mounted four to each broadside. Two more were carried on the upper deck, one forward, the other aft, where they were employed as bow and stern chasers, although they could also be traversed to add their firepower to the ship's broadside. These were 110-pdr rifled breech-loading weapons (or RBLs), newly developed by the ordnance designer William Armstrong.

Instead of using cast iron, his guns were constructed using a steel barrel, reinforced by a series of compressed wrought-iron bands, their thickness calculated to absorb the explosive pressure expected at that part of the gun barrel. This made the guns noticeably fatter around the breech than at the muzzle. Internally the bore was rifled with shallow spiralling grooves, while the shell itself was coated in lead. When the gun was fired the lead would expand into the grooves, and the round would then spin as it left the barrel. The result was – in theory – a shell whose flight was more accurate than one fired from a smoothbore gun. As if this was not radical enough, Armstrong's guns were breech-loading rather than muzzle-loading weapons. His guns ended in a thick metal block, which was screwed into the back of the gun's breech, and could be opened for loading and then closed to form a tight seal.

The 110-pdr Armstrong gun was developed in 1859. This gun had a 7in (17.8cm) bore and a muzzle velocity of 1,175ft per second (358m per second), but disappointingly it lacked the penetrative power of the smoothbore gun. The gun proved unpopular as firing was often delayed, the shell sometimes jammed in the rifling and its flight path was not nearly as accurate as Armstrong had predicted. During the Royal Navy's punitive shelling of the Japanese port of Kagoshima in 1863, there were numerous accidents while firing RBLs – an average of one every 13 rounds. Naturally enough, gunners became so wary of these weapons that in late 1864 the navy withdrew the 110-pdrs from service. While this ended the somewhat premature introduction of breech-loading guns into British naval service, the way the guns were constructed was viewed with favour, as was the basic notion behind rifling their barrels.

Until a reliable form of rifled gun could be developed, the navy continued to use its powerful smoothbore muzzle-loaders. Various solutions were proposed, and all were evaluated by the staff of HMS *Excellent*, the navy's gunnery establishment. The experimental rifled guns designed by Joseph



PENETRATING POWER OF BRITISH M.L. GUNS.

NOTE. – The figs. marked " show the thickness of armour and backing. The figs. 100, 700, 1,300 &c. give the distance in yards.

A comparison of the size and performance of the rifled muzzle-loading guns (RMLs) in British naval service. *Warrior* carried 7in and 8in RMLs after her rearmament in 1867, but by 1870 9in and 10in RMLs had entered service, while the turret ships mounted 12in RMLs. The three largest RMLs shown here all entered service during the decade following 1875.

Whitworth proved to be highly accurate, but were prone to jamming, and eventually the navy declined to adopt them. A 100-pdr muzzle-loading smoothbore 'Somerset' gun was developed, together with a new form of pivot-anchored metal gun carriage, and as ship-smashers these proved very effective, their shells capable of piercing 5.5in of armour plate at 200 yards. They were mounted in the new ironclad *Achilles*, but problems with their carriages absorbing the recoil meant they were eventually withdrawn from service.

The advantages of smoothbores over rifled guns were that they were simple to fire, quicker to reload and placed less strain on the barrel. Rifled guns, though, had a longer range, were more accurate and the velocity of the shell was retained longer than one fired from a smoothbore gun, which meant it was better at penetrating armour. A shunt-rifling system was tried on experimental 6.3in muzzle-loaders, where studded shells were rammed home using one set of wide straight grooves. When fired, the studs would engage in another rifled set of grooves. These proved over-complicated. New smoothbore designs were tried and rejected during 1864, including an improved version of the 'Somerset' SBML mounted in the ironclad *Prince Consort* and guns built using the Armstrong-style wrought iron construction method, but ultimately these designs were rejected and abandoned.

Meanwhile, from 1863 onwards, under the guidance of Captain Cooper Key at HMS *Excellent*, naval ordnance staff tested a number of new rifled gun designs. Key tested another Armstrong RBL, this time a 64-pdr weapon with a modified wedge-shaped breech mechanism, but, although he approved the design, the Admiralty refused to adopt it, as by now it had become convinced that breech-loading ordnance were inherently unsafe. So the emphasis fell on the testing and development of new RMLs. For the most part these guns were designed by Armstrong in conjunction with the Ordnance Department, and

used the construction system he pioneered for the 110-pdr RBL, adapted for use in a muzzle-loading barrel.

In February 1865, a 6.3in 64-pdr 'Fraser' RML was developed and tested, where the steel lining of the barrel was cut with a series of broad grooves, known as 'French' rifling. The studded shell engaged in these grooves, both for loading and firing. After further modifications, the more patriotic term 'Woolwich' rifling was adopted instead. In 1865 the Ordnance Board selected this system as its preferred option owing to the simplicity of its grooving and shell studding. However, the staff of *Excellent* were less enthusiastic, as the bronze studs on the projectile tended to snap off when fired or the shells jammed in the breech. The heavy shell also tended to wobble in flight, so accuracy was less than it should have been. However, the navy had little say in the matter, and ultimately the Board of Ordnance's choice had to stand. As a result, from 1865 onwards, the navy was committed to using this system of large RMLs. It would be over a decade before a better system of ordnance would be contemplated, and 15 years before an efficient rifled breech-loader was mounted on a British capital ship.

Rifled muzzle-loading guns (RMLs) in British naval service, 1865–75

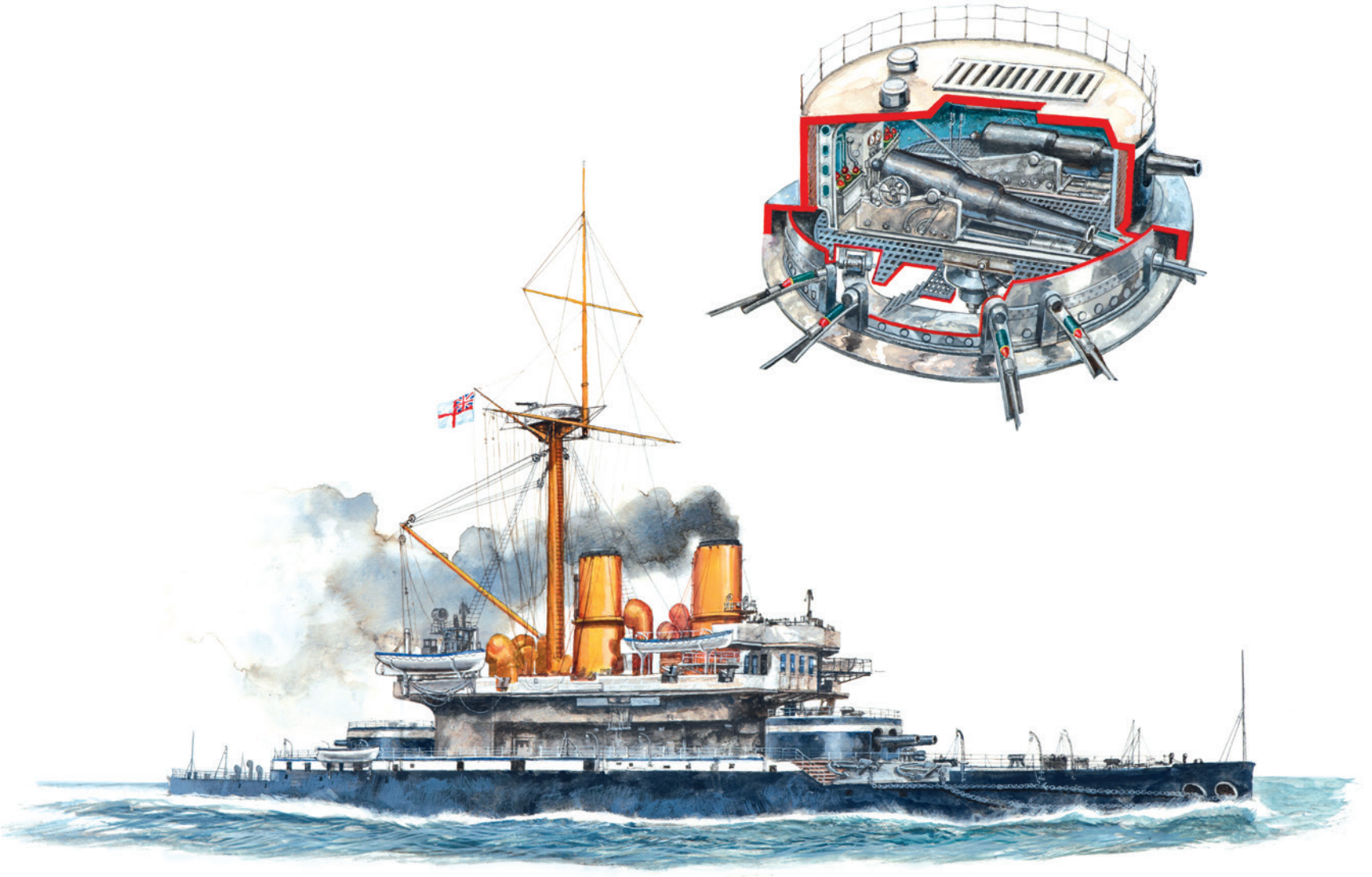
Gun Size	Calibre	Designation	Weight (tons)	Projectile size (lb)	Muzzle Velocity (fps)	Armour Penetration (inches)	Date of Introduction
6.3ft	15.5	Mark I	3.2	64	1,125	-	1864
7ft	15.9	Mark III	6.5	112	1,525	7.7	1865
8ft	14.8	Mark III	9	174	1,384	9.6	1866
9ft	13.9	Mark IV	12	253	1,440	11.3	1865
10ft	14.5	Mark II	18	406	1,379	12.9	1868
11ft	12	Mark II	25	543	1,360	14.3	1867
12ft	12	Mark II	25	608	1,292	13.5	1870
12ft	13.5	Mark I	35	706	1,390	15.9	1871

G

HMS *DEVASTATION*

One of the criticisms of *Monarch* and *Captain* was that their rigging obscured the field of fire of their guns. Masts and rigging were becoming increasingly redundant anyway, as the weight of guns and armour on the latest ironclads made it hard to propel the ships under sail. Similarly, recent advances in marine propulsion had made engines more reliable and cost-effective. So, in 1868, Sir Edward J. Reed drew up plans for a revolutionary type of vessel – one that would render the 'Black Battlefleet' all but obsolete. His turret ship had no sailing rig at all, and only one central mast. Its two turrets each had a field of fire of 270 degrees. Two ships were laid down in late 1869, and these became the Devastation class. *Devastation*, shown here, entered service in 1873, but her radical appearance and the raw memories of the *Captain* disaster meant her sister ship *Thunderer* was not completed until 1877, as the Admiralty wanted to evaluate *Devastation* first. Despite grave reservations of both the public and servicemen, *Devastation* proved a very stable ship, with reliable engines and an impressive amount of firepower. She was refitted and rearmed several times during her long career, and she remained on active service until 1902. Effectively, *Devastation* was the forerunner of the modern battleship.

One of the most innovative features of the Devastation class was the design of the gun turrets. The 12in guns mounted in *Devastation* were loaded by hand, but *Thunderer* pioneered a hydraulic loading system which made the reloading process safer. The cut-away of *Thunderer*'s gun turret shown here shows how this worked: the steam-powered turret was rotated to the loading position, and the gun barrels depressed; hydraulic loading rams would then insert the powder charge and shells into the barrels, the guns would be elevated again and the turret rotated into its firing position. This system reduced the rate of fire to two rounds per minute.

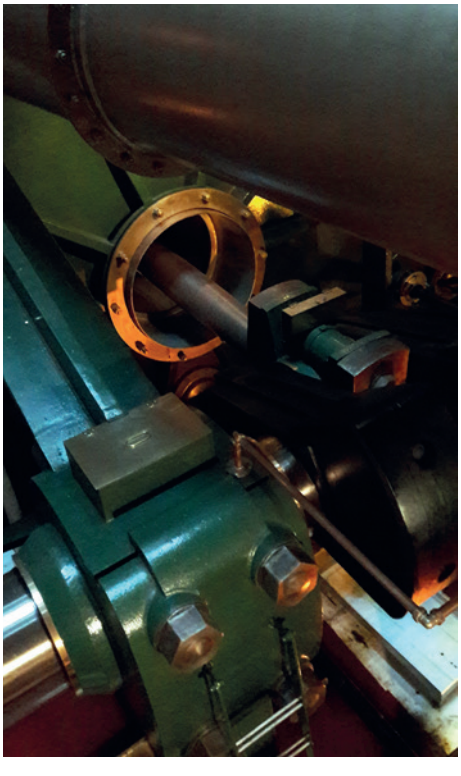


Other weapons

Warrior carried four small 20-pdr breech-loading pieces to use as saluting guns, a practice repeated in other ironclads. There was no call for other small-calibre weapons until the very end of this period. The need to develop them at all was due to Robert Whitehead, the English inventor based in Fiume on the Adriatic, who, in 1866, developed the first self-propelled torpedo. It ran on compressed air, and although it had a range of only around 200 yards (180m), this proved that Whitehead was on the right track. Two years later he demonstrated an improved version, which had a range of almost 700 yards (640m). Two samples were bought by the Admiralty for evaluation, and by 1872 they arranged for Whitehead torpedoes to be manufactured under licence in Woolwich. In 1877, experimental torpedo launchers were mounted in the new central battery ironclads *Temeraire* and *Alexandra*. However, while torpedoes were known about, and even being manufactured, their employment in the fleet took place after the period covered in this volume.

PROPULSION

Old habits died hard in the Victorian navy: while *Warrior* and her successors represented a revolution in naval construction, they were still primarily seen as sailing ships, whose engines merely provided an auxiliary source of propulsive power. That was why *Warrior* and most of her successors had a propeller designed to be disengaged, then lifted out of the water, so its blades did not impair the ship's sailing qualities. Until the arrival of *Devastation* in 1872, all of the ironclads of the 'Black Battlefleet' carried a full sailing rig. This importance began to wane slightly when *Bellerophon* and other central battery ironclads joined the fleet. Their power-to-weight ratio made them mediocre sailing vessels, which in turn meant that their captains relied more frequently on their engines.



HMS *Warrior* was powered by a horizontal single-expansion trunk engine, built by John Penn & Son of Greenwich. Here, one of the ship's two trunk cylinders can be seen in the replica, installed during the ship's restoration, with the crankshaft translating the horizontal motion within the cylinder into a rotary motion capable of powering the propeller shaft.

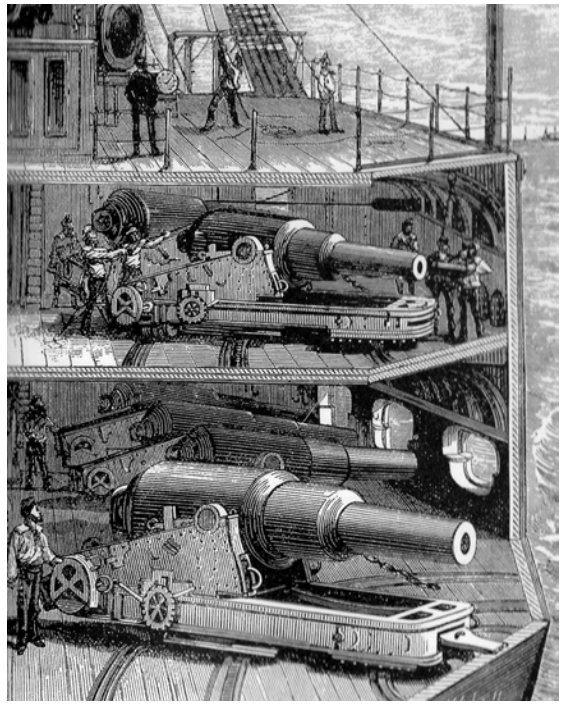
Trunk engines

Warrior was powered by a single propeller, turned by means of a single engine. This was true of all subsequent ironclads until 1868, when the ironclad corvette *Penelope* entered service, powered by two propellers. Twin screws were also fitted in the larger ironclads of the Audacious class, completed in 1870–71. The central battery ironclads *Alexandra* and *Temeraire*, the turret ironclad *Captain*, a group of small coastal defence ships and finally the mastless turret ship *Devastation* were also fitted with a brace of propellers and engines, which of course rendered them less susceptible to breaking down. *Warrior* was fitted with a two-cylinder trunk engine made by John Penn and Sons of Greenwich. Penn was the pre-eminent marine engine builder of his day, having built engines for screw propulsion since the mid-1840s.

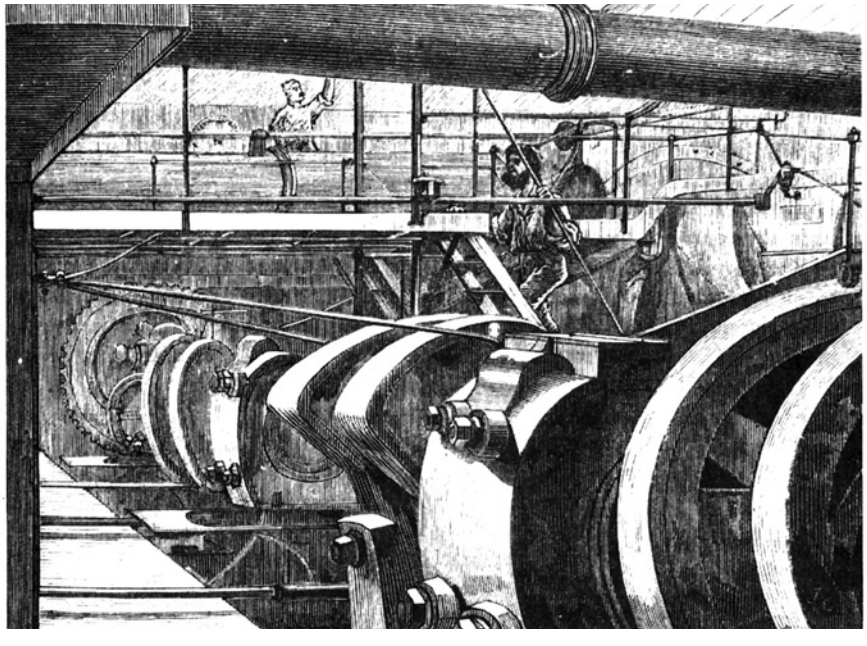
A trunk engine was a form of direct-acting engine, which meant it supplied its power directly to the crankshaft, by means of a piston. The trunk form of a direct-acting engine

occupied less space inside the ship than other versions. The word 'trunk' referred to the way the connecting rod linked to the crankshaft was housed inside the piston itself. In Penn's version, the cylinders (or 'trunks') were mounted sideways rather than vertically, which reduced the height of the engine. This was important as it allowed the engine to be housed below the waterline of an ironclad, thereby protecting it from enemy fire. Penn's 'horizontal trunk engine' was a single expansion system, rather than the double expansion (or compound) systems used to drive the pistons in some contemporary merchant ships. Penn's machine was also 'double-acting', in that low-pressure steam was used to power the pistons at either end of their stroke, which effectively drove the piston both backwards and forwards. At the end of each piston cycle the steam was bled out into a condenser.

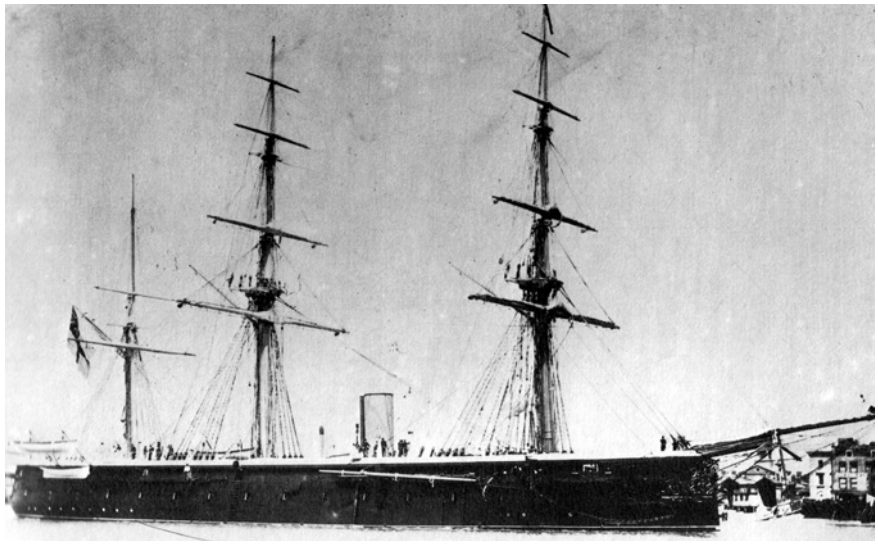
The steam pressure itself was provided by ten boilers, which were also built by Penn. While the earliest boilers were little more than large versions of domestic kettles, this was considered unsafe on board a ship. So *Warrior* used 'smoke tube' boilers, where the heated smoke from the furnace ran through a series of brass tubes, which passed through each boiler, which was filled with sea water. These heated up the water to boiling point, and the steam from these was siphoned off into the main steam pipe, which carried it to the engine. The maximum steam pressure required by these engines was 22psi (1.5 bar), which was considered low-pressure steam, compared to the high-pressure steam used in later marine engines.



A cut-away view of the port side casemate of HMS *Alexandra*, one of the last of the central battery ironclads to enter service. Her upper battery carried 10in RMLs, while below it the main battery was armed with five 11in RMLs on each side. In each battery the fore and aft guns were capable of being trained onto the beam, or else trained either fore or aft, to provide some degree of all-round fire.



The engine room of HMS *Warrior*. She was powered by a two cylinder horizontal single-expansion trunk engine, the cylinders operating the pair of large crankshafts shown here. The engine compartment was separated from the boiler room by a watertight bulkhead.



While HMS *Hector* was officially classed as an ironclad frigate, and was inferior in both size and armament to the larger Warrior class, she and her sister *Valiant* were still powerful warships, despite being considered overburdened by their guns and armour. She is shown here soon after her commissioning in 1864, when she still carried 68-pdr smoothbores on her main gun deck.

When the furnaces were being fired up, the stokers shovelled coal into them, brought from bunkers located outboard of the boilers. The temperature in the stokehold (boiler room) could reach as high as 54°C (129°F) if all the boilers were 'lit'. This, however, was a fairly rare occurrence – *Warrior* and other ironclads usually cruised at a much lower speed, requiring the lighting of fewer boilers.

HMS *Alexandra* was a central battery ironclad – one of the last of her breed – and by the time she was launched in 1875 she was already obsolete, her design overtaken by the more powerful mastless turret ship. Still, she was regarded as a successful ship and spent much of her career serving as the flagship of the Mediterranean Fleet.

Other engines

In 1858, an Admiralty committee recommended that the Royal Navy's larger warships should use only three types of engine – the single piston rod engine, the trunk engine and the return connecting rod engine. The former type was suitable only for small ship engines, and the trunk engine of the kind developed with slight variations by both Penn or Maudslay became the engines of choice. However, in the two ships of the Hector class, return connecting rod engines were fitted, rather than trunk engines. These were a form of steeple engine, where the piston is attached to a crosshead and two rods, which in turn are connected to the crankshaft. Essentially the crosshead is a small metal disc, rotated by the action of the piston, which is attached to one side of it. The connecting rods link this crosshead to the crank itself, but their motion does not necessarily have to be in the same alignment with the cylinder, piston and crosshead. They need to be in a fairly straight alignment with each other, to prevent the piston from jamming inside the cylinder.

In earlier steam engines the piston was mounted vertically, as was the rest of the assembly, so that the whole structure resembled a church steeple. In these ships, though, the piston and its attendant assembly were laid horizontally, along the line of the ship's keel, to reduce the amount of space the engine took up. This arrangement was known as a horizontal return connecting rod engine, or simply a back-acting engine. Both terms refer to the motion of the connecting rod, which

ran back down past the cylinder to turn a centrally located crankshaft. The advantage of this horizontal system was that, like the horizontal trunk engine, it kept the machinery low down in the ship, and therefore in a warship it was located below the waterline. It was also a relatively compact form of engine, which left more space in the ship for guns, coal and armour.

After the engines proved themselves in the Hector class, other horizontal return connecting rod steam engines were fitted in the Prince Consort, Swiftsure and Audacious classes, as well as in *Royal Oak*, *Royal Alfred*, *Zealous* and *Monarch*. They were deemed to be reliable, although not as efficient in terms of coal consumption as the next option, the vertical inverted compound engine. In a compound engine, the steam expanded in the cylinder as before, but then it passed into a second cylinder. Later versions had three cylinders. The advantage was that more propulsive power was gleaned from the same amount of steam. However, these engines relied on high-pressure steam, which entered the cylinder at around 60psi. This in turn required a move to a more efficient kind of circular rather than rectangular boiler, stronger steam pipes and better-designed seals and bearings. It was not until the mid-1870s that these problems were overcome.

Another disadvantage was size. While the vertical engine was robust and efficient in design, and it proved ideal for use in merchant ships, it was deemed too tall to fit inside the hold of a contemporary ironclad: instead it took up part of two decks – the hold and the lower deck. However, by 1875 the engines themselves had been made more compact as well as reliable, and the development of central battery ironclads meant more space was available for engines on the lower deck, as guns were concentrated in a smaller area. *Alexandra*, launched in 1875, was the first British warship to receive a pair of vertical inverted compound steam engines. By then, commercial steamships had been using this new type of engine for a decade, but the Admiralty adopted them only once the reduced coal consumption of the compound engine had been thoroughly demonstrated.

Between 1860 and 1875 the Royal Navy's consumption of coal had almost doubled, and this in turn meant a global network of coaling stations had to be created. Anything that reduced this dependence was welcomed. These compound engines meant the warships needed to carry less coal, which offset the larger space taken up by this type of engine. Other improvements in steam condensers, boiler design and the superheating of steam to render it more efficient all contributed to the increase in engine reliability and economy. This said, *Devastation* and her sister ship *Thunderer* saw a brief return to the Penn trunk engine, albeit in a much improved form. This was because the contracts for them had been signed before the Admiralty's adoption of the compound engine. This made them the last British capital ships to receive this type of engine, and eventually they were replaced by engines of modern compound design.

LIFE ON BOARD

During this period these ironclads were the most powerful warships in the world, a real testimony to British engineering and Victorian inventiveness. However, they were also floating communities, with up to 800 men and boys in them, divided according to rank, living space and duty. Essentially,

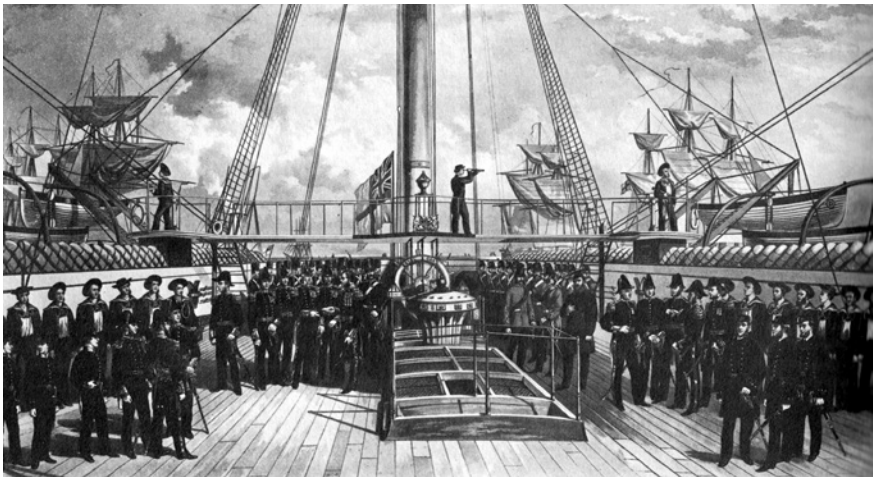
British ironclads like HMS *Warrior* reflected the composition of Victorian society. While her seamen slung hammocks on the gun deck, and her officers berthed in the gunroom or wardroom, depending on rank, *Warrior*'s captain lived in splendid isolation at the stern of the ship, where he had the run of this day cabin, as well as a sleeping cabin and a smaller after cabin.

life on board these ironclads reflected Victorian society, with the captain the unquestioned patriarch whose authority was supported by rules and regulations, the customs of the service and the Naval Discipline Act of 1860. While the old days of press-gangs, harsh discipline and poor conditions were gone, the lot of the Victorian sailor was still a tough one. This was particularly true on board ironclads, where crew comfort was barely considered by naval architects, whose designs emphasized armour, guns and power rather than the well-being of the men.

On the *Warrior*, while the captain lived in splendid isolation aft, enjoying his own suite of quarters, the senior officers berthed in the wardroom and in little cabins adjoining it, while midshipmen lived in the gunroom. Warrant officers and petty officers had their own mess in the cable deck forward, and enjoyed the relative luxury of their own toilets and cook. The bulk of the ship's company – the seamen, Royal Marine gunners, stokers and boys – all berthed in hammocks, hung in the gun deck, and ate at tables erected between the guns. In some ways this was not unlike life on board a warship in Nelson's navy. What had changed though, was that these men were all volunteers, and thanks to the Continuous Service Act of 1853 they were guaranteed employment for ten years, which could be extended for a further decade if requested. Leave was granted for a minimum of four weeks a year, travel vouchers allowed men to return home by railway and on retirement the sailors were even eligible for a pension.

The messing arrangements on a British ironclad were little different to those on board an old wooden-hulled ship-of-the-line. The crew ate at fold-out mess tables and benches erected between the guns on the main gun deck after a member of their mess collected their communal meal from the galley.

A total of 344 of *Warrior*'s crew were seamen and boys, and 116 more were marines. That was much as it had been in Nelson's time, but now these men were joined by a new group. In *Warrior*, two chief engineers, both officers, managed the ship's Steam Department. Assisting them were



The mustering of the crew for 'Divisons' on board the wooden-hulled broadside ironclad HMS *Royal Oak, c.*1866. In this parading and inspection of the crew, the officers gathered on the quarterdeck, as seen here, with the exception of the officer of the watch and two lookouts, perched on the flying bridge.

ten engineers – non-commissioned officers who operated and maintained the engines. These were skilled men, whose technical expertise underpinned this new branch of the service. They were served by 76 stokers and trimmers, including 20 leading stokers. The stokers managed the boilers, while the trimmers brought the coal to them from the bunkers. Working conditions in the engine room and stokeholds (boiler rooms) were frequently unpleasant as temperatures of up to 54°C were not uncommon, and condensation from the steam meant the air was often humid, while in the stokeholds coal dust coated everything, including the men.

Berthing on the gun deck was better ventilated and lit than in traditional sailing ships, but generally sailors preferred their mess spaces to be 'snug', as they got all the ventilation they needed when out on the upper deck or the yards. Mess tables hung from the deckhead were stowed away when the ship beat to quarters (at least once a week) or before gun drills, but otherwise the gun deck would have resembled a sea of humanity when the men were off watch.

George Ballard, then a midshipman, said of the gun deck: 'The bare bleakness of the mess deck with its long range of plank tables and stools had as little suggestion of physical ease as a prison cell. It was damp and chilly in a cold climate, and damp and hot in the tropics. It was swept by searching draughts if the ports were open, and nearly pitch dark if they were closed … as there was no drying room it reeked of wet serge and flannel in rainy weather.' Ballard added that each sailor, 'slung his hammock at night among hundreds of others so tightly packed that they had no swinging room, however much the ship rolled. Even in the head [toilet] he had no individual privacy.'

Sanitary arrangements were primitive, with heads on either side of the bowsprit, much as they had been on board sailing warships. By the later 1860s, however, heads were fitted amidships on the upper deck, projecting over the ship's side, with soil pipes running from them to the waterline. Once a day, each mess drew half a gallon of cold water per man. The crew washed in this, stripped to the waist, then washed their feet and legs to the knee. The water was then used to scrub the mess table and the deck beneath it. Twice a week, the men washed their clothes on the upper deck, two tubs of fresh water allocated for each mess of two dozen men and boys.

The captain lived and dined alone, his suite of day and night cabins at the after end of the main deck, separated from the men by an armoured bulkhead and the half-deck, where his senior officers had their cabins. The captain also had his own heads. The junior officers were accommodated a deck below, on the lower deck. This level was at the waterline of the ship, or just below it, so in iron-built ironclads the deck was divided by watertight compartments. This was the deck which contained most of the ship's storerooms, the cells, the sickbay, engineering workshops, laundry rooms and ship's offices. The wardroom itself was a pleasant enough room, dominated by a large wooden table, with small cell-like cabins running off it. The only light came from small scuttles in the ship's side or from skylights letting in light from the upper deck, two decks above.

The cabins themselves were too dark to dress in without lighting a candle, but while spartan they were comfortable enough. In most ironclads the gun room, where the midshipmen and sub-lieutenants berthed, was located immediately forward of the wardroom. Prince Louis of Battenberg described his accommodation while serving as a midshipman on board the *Royal Alfred*: 'The Gun Room was on the lower deck, that is half under water, with three small scuttles through a very thick ship's side, and consequently so dark that lamps had to be burnt all day. These soon got out of order or smashed, so we were reduced to Pusser's Dips – small tallow candles supplied for the ship's lanterns. These were stuck into empty Squaro bottles – square black gin bottles, of which our senior members kept up a continual supply.'

While the captain, officers and senior rates had their own cooks and stewards, and augmented their rations when they could, the rest of a ship's company had their daily food ration issued by mess table. The mess would elect a cook for the week, whose job it was to draw the collective food ration for the mess, then prepare it at the mess table. It was then taken to the galley on the lower deck, where it was cooked, usually in either a mess kettle or a net bag, marked with the mess number. The prepared food was then taken back to the mess table, where it was served out. Daily rations per man included a pound of fresh meat if available, or else salt beef or pork, augmented by a pound and a half of bread or ship's biscuit, plus a smaller allowance of flour, suet, split peas, vegetables, cocoa, sugar and tea. Each man was also issued with his daily rum ration - a 1/2 gill (1/8 pint, or 70ml of strong rum, issued at noon each day. While Senior Rates could drink it neat, other hands had it diluted by two parts of water, to create a 3/8 pint of 'grog'.

Breakfast was usually eaten at 6–7pm, dinner at 1pm and a small evening tea at 5pm, depending on watches being kept or rank. Breakfast usually consisted of cocoa and biscuits, while tea consisted of food left over from dinner (or rather lunch) – the main meal of the day. Rum was issued at noon. It was a substantial enough diet, and unlike in the days of the old sailing navy the quality of the food was regulated. So too was the supply of fresh water carried on board. However, indifferent mess cooks could ruin a meal, and, at sea, once the fresh provisions ran out, the standard diet of salt meat and ship's biscuit tended to become monotonous. Still, compared with a working man on land, the Victorian sailor was reasonably well fed, decently clothed and the recipient of a regular monthly payment. Pay in 1861 ranged from £9 a year for a ship's boy and £29 for an able seaman, to £182 for a lieutenant and £584 for the ship's captain.

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OSPREY PUBLISHING
Bloomsbury Publishing Plc
PO Box 883, Oxford, OX1 9PL, UK
1385 Broadway, 5th Floor, New York, NY 10018, USA
E-mail: info@ospreypublishing.com
www.ospreypublishing.com

OSPREY is a trademark of Osprey Publishing Ltd

First published in Great Britain in 2018

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A catalogue record for this book is available from the British Library.

ISBN: PB 9781472826893; eBook 9781472826886;
ePDF 9781472826879; XML 9781472826862

Index by Mark Swift
Typeset by PDQ Digital Media Solutions, Bungay, UK

Osprey Publishing supports the Woodland Trust, the UK's leading woodland conservation charity. Between 2014 and 2018 our donations are being spent on their Centenary Woods project in the UK.

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TITLE PAGE IMAGE

The *Achilles* was laid down shortly before the *Warrior* entered service, and she represented a modified version of the earlier ironclad, with a longer armoured belt and protection given to her steering gear. She was also the only British ironclad to boast four masts.